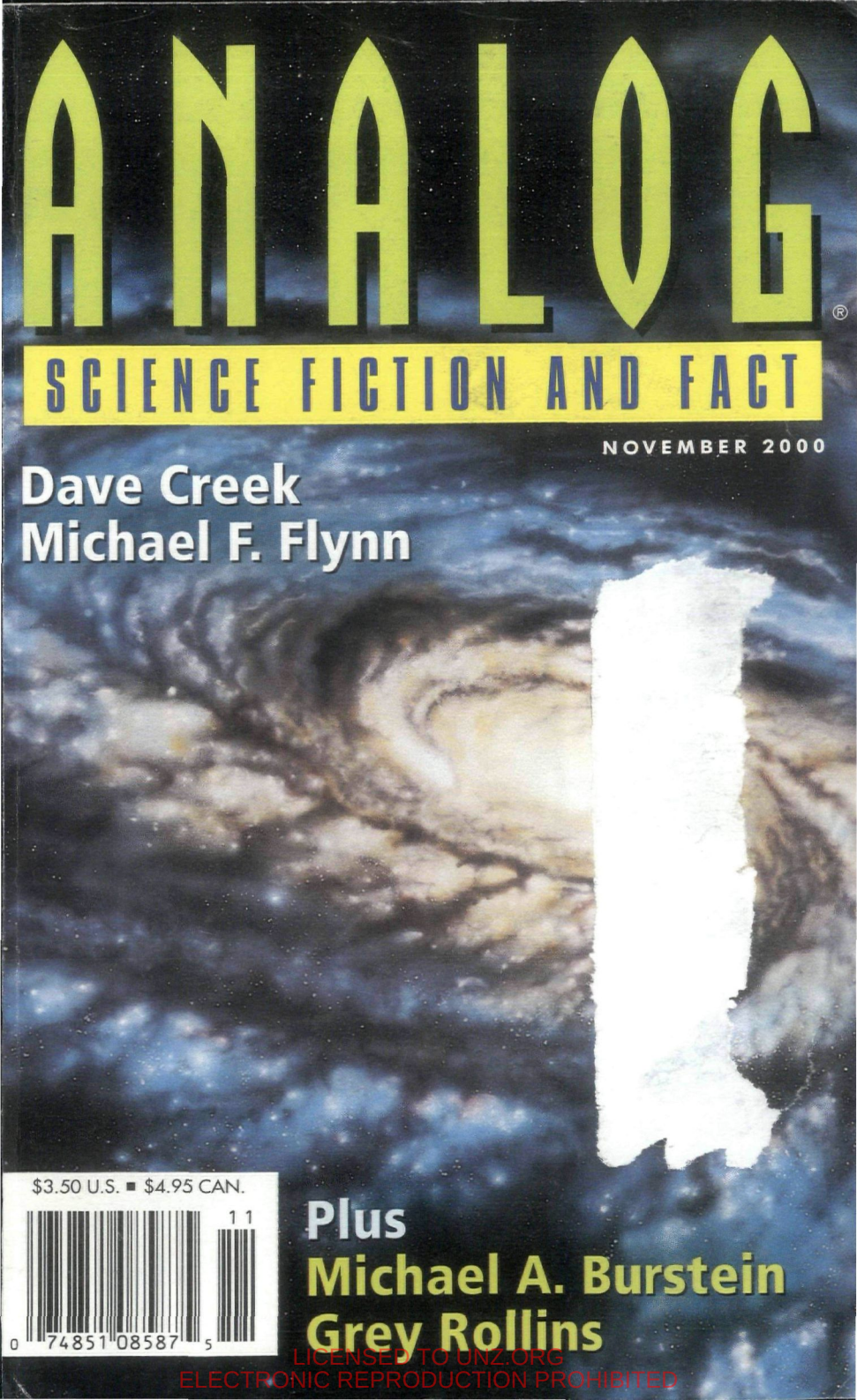

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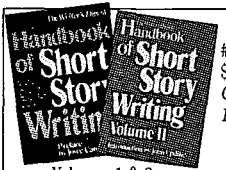

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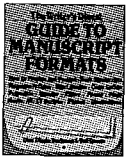

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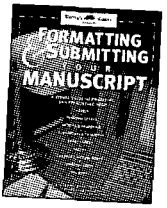

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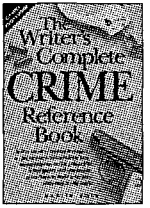

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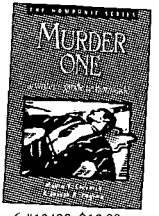

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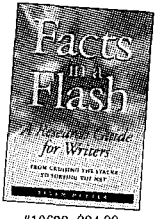

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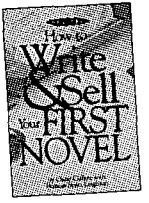

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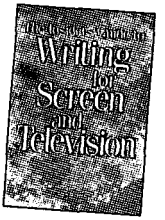

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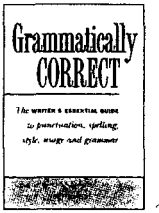

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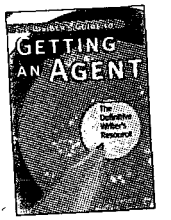

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ANALOG

SCIENCE FICTION AND FACT

Vol. CXXI No. 11
November 2000

Next Issue on Sale
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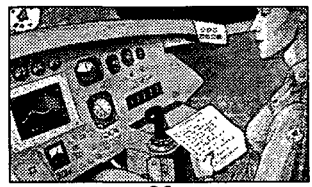

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EDITORIAL Stanley Schmidt

BIG BROTHER AND PINOCCHIO

In a time of rapidly developing technologies, many parallel lines of evolution are going on at once. Sometimes they act synergistically, so that the combined effect of two or more makes something possible that could not be achieved by any one alone. And sometimes they interfere, so that one blocks a goal toward which another seems to be heading.

If you're working on one of those tracks, it may not be obvious that it's on a collision course with another. But it's interesting to speculate on where the clashes will occur and how they will affect the real future—which will be determined more by the interaction of two lines of development than by a simple extrapolation of either.

Consider, for example, the following imminent confrontation. In one corner we have the growing tendency (on which I have previously commented in "Technological Temptation" [November 1999]) of organizations private and public to use automatic cameras to make a visual record of whatever happens in a particular place. Their purpose, we are told, is twofold: to reduce crime by convincing criminal wannabees that they dare not commit crimes because they're sure to be caught; and to provide ironclad, incontrovertible proof of who committed (and how) any crimes that happen anyway.

In the opposite corner we have the explosive growth of digital imaging technology. Digital cameras make it easy to take pictures which are stored in digital form; they can be viewed immediately, and instantly and irrevocably destroyed if, for whatever reason, they are not wanted. Scanners let pictures made by other means, such as painting or conventional film photography, be converted to similar digital forms. Such digital images can be quickly, easily, and cheaply copied and distributed in practically unlimited numbers all over the world. And, most importantly for purposes of this discussion, they can be altered in just about any desired way, with results that are not visibly less real than the original photograph. Such images can even be created out of "thin air," as perfectly real-looking photographs of objects that never existed except in somebody's imagination.

The conflict that is inevitably and rapidly approaching is this. If private security forces and public law enforcement agencies rely increasingly on photographic evidence gathered by surveillance cameras; and if image processing software increasingly allows anyone to doctor any image into any desired form, or create one from whole cloth; how much longer will courts be able or willing to accept camera images as legal proof?

We haven't quite reached the point where the phrase "photographic proof" is a self-evident oxymoron, but we're getting close. Certainly we have long since passed the point where the axiom "cameras don't lie" could be considered any more than a quaint relic of bygone days.

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Actually, cameras have been lying a lot longer than digital hardware and software have been available. Playful photographers have been playing tricks with double exposures and deceptive perspectives for decades, like showing ghosts (in the literal sense) writing novels. Those who did their own darkroom work had even more ways to create photographic "proof" of things that didn't exist or events that never happened, like enhancing or hiding detail in shadow—or substituting *different* details. But such hoaxes usually contained subtle clues that would enable a skilled examiner to determine that a print had been doctored. A picture purporting to prove that a particular person had been somewhere he shouldn't at a particular time, for example, might be a composite of pieces of two photos taken at different times of day and therefore showing different shadow patterns not consistent with a single lighting situation. Making such fakery convincing also required so much skill, time, and effort that it couldn't be done too fast or often.

What has changed with the burgeoning of digital image processing is that it allows images to be changed in just about any way one might like, and with far less time, effort, or specialized skill than with pure camera-and-darkroom methods. Want to make the sky bluer? Trivial! Substitute one person for another in a scene? A little harder, but not much. Show a face or building from a different angle, or with evening or midday light instead of morning? A bit of a challenge, but doable if you have the right software—and if you don't have it, but are sufficiently determined and have enough money, you can get somebody to write it for you.

So a photograph or videotape, in itself, proves nothing, and will prove less and less as image processing technology continues to improve and become cheaper and more widespread. If courts continue to accept records from automatic surveillance cameras as proof of what happened in front of them, they will increasingly have to consider not only what the pictures show, but how much of what they show is real and how much created. The latter will involve such highly uncertain variables as who made them, what motives they might have to be creative, and to what extent they can be trusted not to do so. Such considerations can easily throw so much doubt on what the images mean that they become worthless as evidence. This may happen first in scattered individual cases, but those cases may eventually become so frequent and convoluted that the courts give up on the whole concept.

Of course, I don't expect that they'll give up without a fight. Prosecutors will want all the evidence they can get to bolster their cases, and the citizens themselves benefit from having solid proof available to convict individuals who commit crimes against them. Governments can promise not to doctor

Analog Science Fiction and Fact (Astounding) USPS 488-910 is published monthly except for a combined July/August double issue by Dell Magazines, a division of Crosstown Publications. One-year subscription for $39.97 in the U.S.A. and possessions, in all other countries, $47.97 (GST included in Canada, GST # 123054108) payable in advance in U.S. funds. First copy of new subscription will be mailed within eight weeks of receipt of order. When reporting change of address allow 6 to 8 weeks and give new address as well as the old address as it appears on the last label. Periodical postage paid at Norwalk, CT and additional mailing offices. Canadian postage paid at Montreal, Quebec. Canada Post International Publications Mail, Product Sales Agreement No. 260622. © 2000 by Dell Magazines, a division of Crosstown Publications, all rights reserved. Protection secured under the Universal Copyright Convention. Reproduction or use of editorial or pictorial content in any manner without express permission is prohibited. All stories in this magazine are fiction. No actual persons are designated by name or character. Any similarity is coincidental. All submissions must be accompanied by stamped self-addressed envelope, the publisher assumes no responsibility for unsolicited manuscripts or artwork. ISSN 1059-2113

POSTMASTER: Send change of address to: ANALOG SCIENCE FICTION AND FACT
P.O. Box 54625, Boulder, CO 80328-4625.

IN CANADA RETURN TO: Transcontinental Sub Dept, 525 Louis Pasteur, Boucherville, Quebec, J48 8E7
Executive Office: Penny Press, 6 Prowitt St., Norwalk, CT 06855
Editorial and Advertising: Analog Science Fiction and Fact, 475 Park Avenue South, New York, N.Y. 10016
Subscriptions: Analog Science Fiction and Fact, P.O. Box 54027, Boulder, CO 80322-4027

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photographic records, and may even offer public assurance of safeguards against such fraud, though I'm not at all sure what forms such safeguards might take. Private agencies, being less subject to such protections, are likely to find it considerably harder to get their surveillance records accepted by courts.

But even governments, as I hope we are all abundantly aware by now, are by no means above corruption, and an informed citizenry would do well to keep a very critical eye on its government's use of photographic proof, and any safeguards it claims to be using against potential abuses. Modern technology enables Big Brother to lie very convincingly, and he will frequently have a strong temptation to do so. And, unlike Pinocchio, a well-equipped Big Brother will not have a built-in indicator to tell whether he's lying or not.

Given that the courts are in a sense an appendage of such a Big Brother, they, too, will have to be kept under close scrutiny. Our present government's built-in system of checks and balances provides some protection against their being mere puppets of legislative and/or judicial branches, but it's still possible for the various divisions of government to get too cozy and form too united a front. If we're lucky enough to have courts run by people who take seriously the notion that their job is to provide justice, independently of pressure from other branches, they will be forced to look more and more askance at records that are more and more easily faked—even if they come from official sources.

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First issue of *Astounding* January 1930 ©

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And if they do wind up deciding that the ease of fakery has made electronic records useless, what might they fall back on as more reliable evidence? Ironically, old-fashioned photographic film, by virtue of being harder to alter, is much more reliable as documentation of what happens. Not prints, of course; those are too easy to play games with. But original negatives are very durable and very hard to alter convincingly.

However, their very permanence causes another problem for this kind of application. Making a continuous record of what happens in a store or a parking garage doesn't have to use a lot of storage material, in the long run, because such media can be erased and reused many times. Doing the same thing with film requires a *lot* of film—which will very quickly become a prohibitive amount because there simply isn't that much available. And even if unlimited amounts *were* available, such use would quickly generate vast amounts of negatives, the vast majority of them of no interest, which would have to be either stored or recycled—which is much harder to do than with electronic media.

And, ironically, they wouldn't really be as reliable as they used to be anyway. Film photography does not directly use digital technology, and the film itself is relatively permanent and hard to alter. But its value as evidence is adversely affected by the mere existence of digital technology, because it's perfectly possible to generate or doctor an image digitally and then make a copy of it on photographic film.

So I can't really tell you how all this will ultimately work itself out. I can say quite confidently that the dilemma is coming, and soon. But all I can say about the ultimate outcome is that the rules for dealing with evidence, and legal procedures depending on them, are going to get a lot more complicated!

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The Analytical Laboratory Awards

Back row: Adam-Troy Castro, Sheila Williams, Jerry Oltion, & G. David Nordley. Front row: Stanley Schmidt and James Gunn (Photo: Beth Gwinn)

The Analytical Laboratory awards for 1999 were presented at a luncheon held May 21, 2000, at the Holiday Inn Downtown in New York City, during the Nebula Awards weekend. We were pleased that several of our winners were present to collect their awards personally: Adam-Troy Castro and Jerry Oltion, co-authors of the Best Novella, "The Astronaut from Wyoming"; James Gunn, author of "The Giftie," voted Best Novelette; and G. David Nordley, whose "Democritus' Violin" won as Best Short Story and "Beamriders" tied as Best Science Fact Article. Stephen L. Gillett, Ph.D., whose "Planets X" tied as Best Fact Article, was unable to attend, as was Ron Miller, who received the Best Cover award for his December cover for "Heat."

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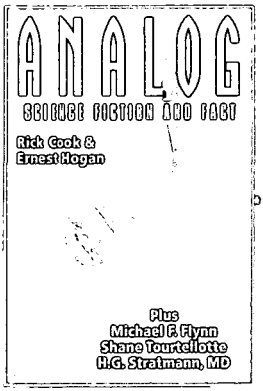

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Swarming Korolev

Dave Creek

Illustration by Vincent Di Fate

It's easy to judge others—when you haven't been in their shoes.

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Mike Christopher and Natalie Kendall ducked around a corner and paused a moment. Mike stood with his hands on his knees, gulping deep breaths. Natalie looked back down the long corridor from which they'd come. Korolev Habitat was a cylinder only a kilometer long, but they'd both run nearly its full length. And Mike could hear the Jenregar scouts gaining on them.

He was wondering what to do next when he saw what he was looking for. More importantly, he smelled it. A cramped storage space beneath a pedestrian ramp. He grabbed Natalie's arm. "In there." They might elude the Jenregar yet.

Natalie was taking quick, sharp breaths. The better to notice the stench coming from the pale green, cylindrical waste canisters crammed into the storage space. She blinked her piercingly blue eyes, shook her mane of coal-black hair, and told Mike, "Forget it. You don't want to know what's in those canisters."

Now Mike glanced around the corner. No Jenregar scouts visible yet, but they had to be close. He looked straight up. The Jenregar presence was most visible 180 degrees and .2 kilometers overhead, where Mike could see the neighborhoods, farms, and parklands Humans had abandoned as the previously unknown species had overrun them. "They'll catch up to us soon," he said. "We have to hide."

"The *recycler's* out on this block. The techs have been packing everything from Human waste to soured milk in those things."

"That's what I'm counting on," Mike said. "And this is where I'm hiding." He bent to squeeze himself into the storage space. "You do what you want."

Natalie muttered something that Mike was probably glad was unintelligible, then said, "Move the heck over, then."

Natalie's squeezing into the already-confined space pushed Mike more closely against two of the nauseating waste canisters. Thankfully, they were not spilling any of their contents, but Mike gagged just the same. "*Quiet,*" Natalie told him. "They'll hear us."

"I can't help that I smell better than most people."

"You mean you have a better sense of smell. Neither of us is going to get out of this smelling very good."

"They're close."

"I don't hear—"

"Remember that musky smell they have?"

"You *are* good, if you can smell *that,* even over—"

"Artificial Human. Augmented senses." To anyone who didn't know Mike's origins, the mixture of tightly curled hair, light brown skin, and blue eyes with small folds of flesh covering their corners would have given them a clue.

Both Mike and Natalie were trying to push themselves farther behind a row of smelly canisters when three Jenregar scouts rounded the corner.

Their bodies were hard carapaces that appeared black until you glimpsed highlights of a deep red. Each stood about .75 meters tall. Their legs bent "backwards" to a Human eye, and though thin and bony, looked strong. Their "arms" appeared boneless, each movement sinuous and flowing. Three-fingered hands, with the presumed "thumb" sporting a mean-looking stinger. Mike had seen just minutes earlier what those stingers could do. Five Humans dead, right before his eyes, all within seconds. He and Natalie had barely escaped.

Jenregar faces had no noses, and their mouths were mere slits. They stalked down the corridor and would pass right by Mike and Natalie's hiding place within seconds.

Natalie whispered, "Scoot back further. They'll *see* us."

"Maybe not," Mike said. "Look at their eyes. So small. And those flaps of skin on the sides of their heads. All they have for ears. Both secondary organs, I'd say."

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"So how do they perceive anything?"

"See the stubby protuberances atop their heads? Almost like antennae?"

"I get it. Scent receptors. Their primary sense?"

Mike only nodded as the three Jenregar drew closer. Then they paused simultaneously, none seeming to lead the others. Their antennalike organs pivoted slightly. They did not look around, never casting their gazes toward Mike and Natalie's hiding place. Then they moved on.

Only now did Mike become aware of his pounding heart. "Let's stay here another minute. Just in case."

Natalie said, "You knew they wouldn't see us."

"Didn't know. Guessed. We live in a world of sight and sound, mostly. Theirs is smell and taste. I hoped we'd confuse them. I noticed how their antennae and their eyes worked when. . . ."

". . . the others were killed?"

"Yeah," Mike said. "We shouldn't have tried to parley. I should have figured that out sooner."

In retrospect, the attempt to make peace with the Jenregar had been naïve and uninformed. A week earlier, a single craft had fallen out of stardrive and begun sending over shuttles that quickly and efficiently figured out how to mate with the habitat's locks and pierce its hangar decks' force fields so they could begin disgorging Jenregar scouts. Those beings quickly overran entire neighborhoods, occupied homes and public facilities, and stung to death anyone who resisted. Human stunners did not work against them, and disruptors were in short supply. Force shields protected neighborhoods only so long against Jenregar incursions. They apparently worked without sleep and went for long periods without eating. They would probe, then pause, as if waiting for unheard instructions, then probe some more until they would discover a counteracting beam that would tear through a shield or a resonance frequency that would disrupt it. Then more Humans would die or fall back, and the Jenregar would advance another few dozens (or hundreds!) of meters.

And the sheer *numbers* of them! If a thousand Jenregar descended upon a neighborhood whose shields had fallen, it didn't matter how many of the mere dozens of Humans had disruptors, they were quickly overrun. No forms of communication had worked, and the Jenregar ship had made no transmissions toward the habitat.

Mike was chief contact officer of the exploratory starcraft *Asaph Hall,* and Natalie, who was a Korolev Habitat councilwoman, was an old friend. She called on him when she'd learned the *Hall* was only days distant.

Mike, to his horror, found habitat mayor Gordon Riley about to leave on a peace mission top-heavy with self-important politicos who'd never been involved in a First Contact situation. Mike failed to convince Riley of the obvious dangers involved and reluctantly went along on the ill-advised mission into the occupied area. Soon they confronted a phalanx of about a dozen Jenregar scouts who stopped short when confronted with a Human presence.

Riley must have known verbal communication wouldn't work, with the Jenregar language not in anyone's datalinks, but he tried anyway, without success. Sign language, transmitting prime numbers on subspace frequencies, wild gestures—all equally futile.

And that was about it. Alternatives quickly exhausted, the Humans just stood there, waiting for any response. When the scouts stepped forward without preamble and began grasping men and women by the necks and stinging them, Mike knew he couldn't help the others; the Jenregar's thumb stingers pierced an enemy's skin and inserted acids that injured and immobilized you, and poisons that finished you off within minutes if the acids didn't do the job. Mike didn't even try to pull his stunner,

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just grabbed Natalie by the arm and they got the hell out of there.

Now, still hiding behind filthy waste containers, Natalie put a hand on Mike's shoulder. "None of this was your fault. Were you supposed to knock Riley on the head and keep him from going?"

Mike said, "I'm the contact specialist. I should have figured something out." He shoved a container aside. "Let's get going again." The Jenregar had swarmed over about a quarter of the cylindrical habitat's area, in the process killing dozens of Humans and displacing nearly two thousand out of the current population of five thousand. An impractical number to evacuate quickly, though Earth Unity craft were on their way just for that purpose. Though at the rate of Jenregar expansion, the evacuation craft and the promised light cruisers would arrive too late.

Once out of hiding, Mike glanced around. No Jenregar in sight, and the musky odor they exuded constantly was fading. Mike looked up. About 45 degrees from their current position in the cylinder, he could see the nearest checkpoint, and safety. He and Natalie started around the curving floor of the cylinder, didn't encounter any more Jenregar, and made it there within minutes.

With the death of Gordon Riley and several of his assistants, Natalie Kendall was now Korolev Habitat's mayor. Once past the Human checkpoint, though, Mike agreed that their first stop should not be the makeshift command post four blocks away, but Natalie's home just inside Human-held territory. "You need to let your family know you're OK," he said. Especially, Mike knew, since word of the massacre must have gotten out by now. After all, surveillance of public areas was easy in an inside-out world—just look all around.

Mike lagged behind as Natalie's husband Ralph rushed out of the single-story home they shared with their four-year-old boy, Duncan. As Ralph and Natalie embraced, Mike couldn't help but notice the first signs of the home's neglect. The house's smart-tech had been shut down for the emergency. So now individual blades of grass reached a fraction of a centimeter higher than others, a gurgling pond had a faint layer of scum on its surface, and the house's windows needed washing.

"Mommy!" Duncan bolted out the door and jumped into Natalie's arms. She held him close and spun him around, her eyes closed and a broad grin on her face, a grin mirrored on her child's chubby-cheeked features. Mike watched, fascinated. Such closeness between family members was always a novelty to him. An artificial Human had no progenitors, no family history.

Ralph Kendall shook Mike's hand. He was a swarthy, bearded man with long black hair tied back in a ponytail. "We were watching a live feed of your encounter with the Jenregar. I wanted to thank you for saving Natalie."

Mike shook his head. "I should've warned the others more forcefully."

"I watched Riley in action more than once. You'd never have convinced him to stay behind. I'll mourn his death, but he was too headstrong."

Natalie kissed her son's cheek and placed her hand on the back of his head. "It's too dangerous to stay in this house. You and Duncan have to go farther back."

"Natalie, we can hold things together here for awhile longer. . . ."

Natalie put her son down. "Duncan, why don't you go in and grab the things we packed for you yesterday?"

"Yippie, we get to go to Gran'ma-ma's!"

Mike said, "Maybe I'll help him look—"

"No, you won't," Natalie told Mike, and froze him with a stare. "You're my witness to how quickly the Jenregar can move. How deadly those stingers are."

Mike looked at Ralph. "She's telling you the truth. And she's right. You need

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to leave."

Ralph set his stance as if bracing himself against a deadly blow.

Natalie was having none of it. She said, "We're not a military colony. We were foolish to come out this far from Unity support. Ralph, *please.* I have to know you and Duncan are safe, so I can do my job."

Duncan came back out of the house, dragging a child-sized backpack bulging with whatever a four-year-old considered essential. "Please, Daddy, can we go, please?"

Perhaps Duncan's eagerness helped. Ralph's shoulders slumped. "All right. We'll go." Mike had never seen such a palpable sadness in a man's eyes. Ralph told Natalie, "There's only so far we can go in a cylinder."

Natalie cupped her husband's face with one hand, and he placed his hand over hers. Mike looked away, not wanting to intrude on such an intimate moment. A family moment. Natalie said, "Mike and I have to figure out what to do until the Unity gets here."

Ralph told Duncan, "Help me get the bikes, please." Mike had no words. He found Humanity the most mystifying Galactic species.

Korolev Habitat orbited its primary, Shelton's Star, at a distance of 1.1 A.U. The cylindrical world was eventually to house ten thousand people, but only half that number had arrived. It spun at 2.85 rotations a minute, giving the artificial world's interior a one-*g* grav. That interior, though, was not fully landscaped and construction of many of its neighborhoods had not been completed.

The command post was an uninhabited single-person dwelling near the habitat's northern cap. The Jenregar had made most of their advances from the south. Mike and Natalie stood in the home's living room, staring at a holo of the habitat's interior. Mike's associate from the *Asaph Hall,* Linna Maurishka, had joined them. She said, "We still haven't discovered enough about the nature of the Jenregar. We can't communicate with them. And I've been just close enough to a few of them to tell you I can't read anything from them." Linna was an empath. In fact, she could not turn her emotion-sensing abilities off. Though she and Mike were shipmates, monogamous while on-ship, they did not share quarters. Linna couldn't stand the constant presence of another's emotional radiation.

Natalie pointed to a couple broad swaths of green in the Jenregar-occupied zone and said, "They're taking over the farms first. If they don't overrun and kill us, they'll starve us out." Natalie's voice nearly faded away at the end, and Mike thought she was staring at the holo without really seeing it.

He asked, "Do they appear to be eating Human food?"

Natalie didn't look at him. "We've seen that through our 'scopes."

Linna said, "They make use of tools. It's hard to imagine a sentient species that didn't have that capability. Though I never thought I'd see a sentient species with tentacles, either."

Mike said, "They're called biological hydrostats. They maintain their shape by internal fluid pressure. Like, well, the Human penis."

Linna laughed. "Thanks for *that* delightful image."

Mike joined Linna in the light moment until he saw Natalie's sober expression. "What is it?" he asked.

She said, "I've seen the Jenregar before."

Mike was astonished. "When?"

"Ten, no eleven years ago. I was starting up the Human science post on Anaktuvuk. Ever been there?"

Mike shook his head. "Only nearby."

"It's barely habitable. A lot more UV radiation than Earth. It's about to enter an ice age. That's when I first encountered the Jenregar."

"What happened?"

"I was with an advance team on the

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planet's surface. An exploratory craft, the *Angra,* left a dozen of us to get the station started. Building a shelter and getting established only took a few days. Then we started exploring, sometimes just walking around. That's what happened to three of us the day the Jenregar found us. Me, our geologist Fletcher Merryweather, and Susanna Donsa, our biologist. We encountered about a hundred Jenregar. We hadn't detected a ship in-system, so we thought they were indigenous."

"They didn't show up on scans?"

"Not as sentient beings."

Linna asked, "And something went wrong?"

"Very wrong, very quickly. Fletcher and Susanna and I were in a valley, very rocky, sun beating down hard. We had our lifesuits going against the UV and the cold. The Jenregar just *poured* over one ridge. They were like ants. I think that's what. . . ." Natalie ran out of steam and looked around for a place to sit.

Linna asked, "How about some water?"

Natalie found a chair with a hard back and sat, straight and stiff.

Mike turned off the holo of the habitat. He sat on the edge of a more comfortable chair as Linna brought the water. "Thanks," Natalie said. A sip of water, then: "We assumed they were attacking. They came across that ridge like ants, or scuttling cockroaches. I think that's what made killing them all so easy."

Mike gave his old friend a long look. "You *killed* members of a species you knew nothing about?"

Natalie wrung her hands. "They *swarmed* over us. We wouldn't have had disruptors if we'd thought we'd be in a First Contact situation, we'd've had stunners, you know the custom. But Fletcher was going to do some digging, we all had hand disruptors to help him excavate." The hand-wringing stopped, then Natalie pressed her palms against her face.

Mike said, "And you turned the disruptors on the Jenregar."

Natalie's voice was muffled behind her hands. "Yes."

"A bipedal species."

"Yes."

"Acting with purpose."

Whispered: "Yes."

"Just *slaughtered* them?"

Shouted, fists clenched: "*Yes!*" Then, in a more even tone: "They came so fast. And after we started shooting, they stung Susanna in the leg, and her screams were so loud. . . ."

"They stung her *after* you started shooting?"

"We were so scared."

Mike glanced at Linna. A slow nod from her. He understood. Linna's empathy confirmed Natalie was speaking the truth, at least as Natalie perceived it.

"What happened afterwards?"

"All the Jenregar . . . of course we didn't know then that's what they were called . . . were dead. We exhausted our disruptors turning them to ashes. The wind started blowing them away even as we climbed out of the valley."

Linna asked, "And when you reported to the others?"

"We decided not to say a thing. We were all so scared, we talked all the way back, we figured out they had to be sentient, but in a way we'd never seen before. I treated Susanna's leg, she wasn't even limping by the time we got back. She was lucky the Jenregar that stung her didn't inject any poisons. We were just trying to protect ourselves, but we knew too many people who wouldn't see it that way. They'd see some kind of . . . genocide or something."

Mike didn't say anything. He was one of those people. Secrets. Only on such a frontier could a Human commit such an act in concert with others and conceal it for so long.

Linna asked, "Does your husband know?"

"I've never told Ralph. And the others—Fletcher thought we were ab-

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solutely right, both to shoot and to keep quiet about it. Susanna had doubts. But I heard she was killed on Ptolemy, in the Sapphire System. Some sort of philosophical argument that turned sour. With a Relajem."

Mike nodded understanding. Some of them could be pretty adamant in their views. And liked using their snakelike bodies to squeeze Humans to death. "And you never encountered them since?"

"I'd hear things. But it was always in a port or a bar somewhere, and always from beyond Human-explored space. I thought since we'd killed all of them we saw there on Anaktuvuk, maybe others of their species never found the remains. Or maybe they just 'seed' a lot of colonies and leave them alone. Then I met Ralph, we had Duncan, and a habitat became a lot more appealing than exploring. I think part of me was afraid I'd come across the Jenregar again."

Mike said, "And now they've found you."

"Not me. Humanity. They are very much like ants, you know. You're right about them living in a world of smell and taste. I think the scouts and protectors and all the other specialties they have take chemical cues for their behavior. Other responses are hard-wired."

"But why would they come here?"

"The Jenregar is actually an 'it,' not a 'they.' It decides things slowly, as a unified entity. If parts of it somehow managed to get back onto Anaktuvuk undetected, and discovered the remains of those scouts, it would also have discovered Human DNA, and even Human scents."

"*Could* they have done that, undetected?"

"The Human outpost is small. It has nothing anyone wants, and the scientists there are only concerned about their research. They don't get a lot of visitors and don't keep an eye out for them. Besides, the Jenregar has excellent shroud capabilities."

Mike leaned forward. "So it could have recognized this as a Human habitat. Shrouded, gathering up the inevitable small bits of debris and waste material any Human artifact in space gives off. Recognizing our DNA signature."

Natalie pressed the tips of her fingers to her temples, as if warding off a headache. "Yes. And from what little I've found out over the years, that first encounter on Anaktuvuk may have led it to leave Humanity alone awhile. But that was over ten years ago. It may have changed its mind."

Linna said, "And become more aggressive."

"That's right."

Mike stood. "I've had enough of this."

Natalie's eyes wouldn't meet his. "Please don't tell Ralph or Duncan what I've done." Then, after an awkward silence, "You're disappointed in me, aren't you?"

"Of course I am. But I can't think about that now. We have to save this habitat. Which means we need some help from the *Asaph Hall*."

Mike and Linna stood within the observation deck overlooking the hangar bay at the unspinning hub of Korolev Habitat's northern cap. This was the only part of the habitat with artificial grav, to avoid the painfully-slow process of zero-*g* docking, embarkation, and loading or unloading.

The *Asaph Hall* was a steady point of light ten kilometers distant. They watched as the *Hall*'s shuttle *Phobos 2* glided into the bay. Aboard were exobiologist Rishona Kwan and communications and ecology specialist Georges Remy. Mike needed their help to carry out the plan he was still formulating, which his feelings about Natalie were preventing him from focusing on fully.

He felt Linna's hand on his arm. She wouldn't ask how he felt. An empath knew.

It also wouldn't do to put a good face

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on things. "I wouldn't have believed Natalie could. . . ."

"Kill coldbloodedly? Cover it up?"

Mike blinked. "Yeah."

"How well did you know her?"

"I met her twelve years ago. Before the Anaktuvuk incident would have happened. I was between assignments. We met at the Solar Plus Music Festival in New Queensland Torus. I used to go every year. We were sitting next to each other one night and we started talking between acts."

Linna asked, "*And?*"

Mike knew how many questions were contained within that one word. "We were never lovers. In fact, we tried to go out on a date once, and just started laughing in the middle of it. We stayed buddies."

"Uh-huh."

Mike thought it best to maintain forward motion. "She was bright and funny and I could tell she was dedicated to exploring, every bit as much as I was. I thought I was talking to someone whose name would be on every Human's lips, given enough time. I was surprised when she and Ralph settled down and had a child. They lived on *Earth* for awhile. Don't look at me that way, I know Earth isn't that bad. But I wanted someone to look up to."

Linna said, "And she's failed you."

Mike looked out onto the hangar bay. The *Phobos 2* was settling onto the bay's floor. "Yes. She has."

Mike and Linna went to the hangar deck to greet Rishona and Georges. Rishona's combination of Mideastern and Asian features sometimes meant she was mistaken for an artificial Human; Mike had a similar combination of traits, though his were imposed rather than inherited. Georges was short and balding and wore a habitual smile.

After handshakes all around, Georges said, "The Jenregar are sending a lot of shuttles back and forth. About every half hour." So far the Jenregar starcraft, all rounded surfaces and blotchy light blue and purple markings, had remained stationkeeping about two kilometers away from the habitat's southern end. It looked organic, more grown than built. It appeared uninterested in the *Asaph Hall* so far, which was fortunate given that the *Hall* was a lightly armed exploratory craft.

"I think I know why," Mike said. "And it could be the key to saving this habitat."

This time the holo in the center of the command post's living room was of a dissected Jenregar, its skin folded back along its midsection and along its limbs to show the organs and muscles beneath. The four *Asaph Hall* crewmembers gathered around the image, along with Natalie. Mike hadn't said anything to Rishona and Georges about Natalie's first encounter with the Jenregar. He wanted them concentrating on the problem at hand, not another's sins.

Mike pointed to the image of the Jenregar's hand. It had three digits. He pointed to the thumb. "Opposable. We've seen what the sting and its poisons and acids can do." He pointed to the area beneath the Jenregar's arms. "More poisons here, but also the capability to emit pheromones. This is the Jenregar's primary form of communication. And I believe it's the reason for those frequent shuttle trips to and from their starcraft."

Georges smiled, as he always did, but his expression was tinged with admiration. Mike wondered if it was for him or the Jenregar. "They're couriers! They don't use verbal communication at all. That's why we haven't detected any transmissions from their ship."

Rishona stepped closer to the image. "It's ingenious. But not very practical for a spacefaring species."

Mike said, "I guess it'll have to do until they find a way to transmit odors through subspace. Now, Rishona, Georges, we have some Jenregar corpses, and air samples taken near liv-

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ing Jenregar for you to examine. Natalie says their social structure resembles that of ants. Well, we're going to find out if they have a queen. And to do that, we need a disguise."

Two days later, Mike and Natalie approached one of the many Human checkpoints next to Jenregar-occupied territory. Helmeted security officers with stunner rifles at the ready stood behind crude barricades of electric-powered touring carts, support structures ripped out of homes and offices, and even furniture. Beyond, a force shield shimmered. Past that shield, the Jenregar waited.

"Ready?" Mike asked Natalie.

Natalie took a deep breath and looked as if she were gathering inner resources.

"You don't have to go."

"I'm ready."

Mike frowned. Linna had fought to go with him, but her empathy was useless with the Jenregar and Mike wanted someone with him who knew the habitat interior intimately, who could help him find his way across the Human landscape the Jenregar was already altering for its own purposes. Mike realized it was a calculated risk.

He said, "Activate lifesuit," and pressed his left hand's middle finger into its palm. The personal nanotech that normally would wrap a spacesuit around Mike now encased him in energy fields and biofields that would make him smell and taste like a Jenregar. The musty Jenregar scent filled his nostrils.

He watched as Natalie activated her own lifesuit. She looked no different; Georges and Rishona had had too many difficulties emulating Jenregar smell and taste to worry about sight or sound. Given time, they could even have developed a tactile protocol that would have completed the illusion.

They didn't have that time; Jenregar scouts were pressing forward, and Human survivors were being crowded into a smaller and smaller area of the habitat.

Mike checked his disruptor. No standing on spacer custom or protocol here. They would be cut off utterly from any Human support, even communication with the habitat or the *Asaph Hall*. That was partly by design; he'd decided not to take the risk that the Jenregar could detect electromagnetic or even subspace radiation and target him and Natalie as not one of its own.

Which was also why he'd resisted Linna's suggestion to take a bomb onto the Jenregar craft; he didn't want it detected and possibly turned against the Humans inside the habitat.

"Let's go," Mike told Natalie, and nodded to one of the security officers who lowered the force shield just long enough for Mike and Natalie to step into the Jenregar's realm.

Jenregar scouts were waiting.

There were five of them, and once again Mike watched as the Jenregar antennae pivoted atop their heads, as their eyes remained focused straight ahead, their arms moving sinuously. Only this time, rather than hiding behind waste containers, he and Natalie were out in the open. Mike resisted all his body's instincts, summed up as, *Get the hell out of here.*

What happened next was anticlimactic; the Jenregar moved on down the street.

Natalie looked at Mike. "I can barely believe this actually worked."

Mike said, "Imagine a being who looks and sounds just like a Human. Would you think anything about an unfamiliar scent on that person? You might not even notice it. All the same, we can't get overconfident. The front-line scouts are probably pretty low-level when it comes to decision-making. The farther behind the lines we go, the more likely it is we'll have to respond to pheromone cues."

"Which we'll have no idea we're supposed to be receiving."

"And no way to interpret if we did. Let's head south."

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They did, and saw that the Jenregar had already begun the process of making Korolev Habitat its own. The closer they got to the southern cap, the fewer intact homes they saw. They were being dismantled, and their raw materials recycled, to make Jenregar housing. That housing was not geared toward individuals or families, but toward swarms of Jenregar.

If Human homes provided the raw materials, then the habitat's broad parklands made the perfect building sites. A giant mound of material ripped from homes and shredded or molded into the Jenregar's desired shapes sat in the middle of one park. It stood four times Mike's height and looked to be over half a kilometer across. He wouldn't have known whether to describe it as a piling or a weaving of material. Red-backed Jenregar scouts, along with blue protectors and yellow builders, came and went in a constant stream, strangely silent except for the sound of their quick footsteps on pavement or grass.

Mike was amazed at the industriousness, and the sheer numbers of Jenregar individuals, that they had been able in just over a week to create such a structure while continuing their conflict with the habitat's population. "They don't waste much time, do they?" Mike asked Natalie.

"They only care about survival. No art or music. No politics. Every decision unanimous. No emotional component. They only attack if they perceive a threat."

"And they perceive Humanity as a threat."

Natalie flinched. "Because of me."

"Yes."

"It took them over a decade to find us."

"A decade we could have been preparing for them. Look, I'm sorry. Let's deal with what's in front of us."

The two Humans traversed the length of the habitat's interior, and waited until they could take an empty lift up to the southern hub. They stood on the hangar deck next to a Jenregar shuttle. Its exterior was the same deep red as a scout's carapace. It was shaped like an egg cut in half lengthwise, rounded at the top and flat on the bottom. Jenregar scouts, builders, and protectors were all around. Mike and Natalie remained unchallenged. Dozens of scouts stood, docile and unmoving, next to a larger shuttle, apparently a troop transport, that had arrived minutes earlier.

Dozens of Jenregar builders were hard at work in one corner of the hangar bay. They were using substances they excreted from their thumbs and from beneath their arms to break apart interior walls, desks, chairs, and anything else they could use to build a smaller version of the mounds Mike and Natalie had seen within the habitat.

Except for the hissing of the corrosive substance the builders were using, and the sounds of metal and plastic being broken apart or ripped into shreds, all was quiet. No murmur of background conversation, no shouted orders.

"This shuttle looks organic," Natalie said.

"It may well be. That could go back to how the Jenregar perceive things. For us, sight and sound let us understand physics more easily. Smell and taste are rooted more in biology, so maybe that's how they approach their tech."

"Organic nanotech?"

"I don't see why not. Even we talk about 'growing' shuttles or buildings."

"Mike, if there is a queen, and we find her—what are you going to do?"

"Confirm that she exists, then get the hell out of there. Rishona set our lifesuits to take constant microsamples of Jenregar pheromones. Maybe we can figure out how to communicate after all."

"I'm not optimistic. And if they detect us, the Jenregar isn't exactly the forgiving sort. We're going to need a weapon. An overpowering weapon."

Mike saw a Jenregar scout emerge from a lift and stride purposefully to-

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ward the smaller shuttle. "I'd bet that's our courier," he said. "Maybe he won't mind a couple of passengers. C'mon." They fell into lockstep behind the scout. An entrance . . . *peeled open* was the phrase that came to Mike. It was as if multiple arms were opening to welcome him and Natalie in. Or as if a carnivorous plant were about to envelop them. The entrance folded shut behind them.

Then, darkness. Mike could hear the Jenregar moving around, but couldn't make out what was happening. No instrumentation gleamed at him, no holos or other readouts. Then, a disturbing quiet.

Natalie's voice came from right next to Mike. "We'd better find a place to sit."

"You don't have to whisper. Either the scout hears us and it doesn't matter, or we're dead anyway."

A loud bump and a clatter next to Mike, and a sharp cry of pain from Natalie. "I guess you're right," she groaned. "I hope my foot doesn't swell. I'm trying to find a seat. *Oh,* goodness."

"What happened?"

"I touched the scout."

"Did he react?"

"I don't think so."

"Let's sit somewhere behind him, if we can."

Another clatter, not as loud this time. Natalie said, "We may have to hunker down on the floor. I can't find any seats."

The shuttle began to move, presumably headed for the main bay doors. Natalie found Mike's hand and she guided him down next to her against a rear wall. Mike let go of her hand. That continued touch would have reflected a casual intimacy at one time, but it was an intimacy Mike didn't feel now.

He wondered how aware Natalie was of his feelings, sitting so close to him now, in darkness and silence.

Then those thoughts vanished as a brutal acceleration gripped the shuttle. No inertials, Mike realized. He groaned as a great weight bore down on him, massive *g*-forces he wasn't used to experiencing. He imagined he could feel his internal organs rearranging themselves. If he hadn't already been pressed up against the shuttle's rear wall, he could easily have broken some bones. He'd suffered broken ribs in high-*g* before, and it wasn't fun.

Fortunately, it was all over in seconds. After all, the Jenregar craft was only ten K distant. Mike wondered how much acceleration the Jenregar could withstand. If it had been much more, or for longer, Mike would have blacked out. Or died of internal injuries. "You OK?" he asked Natalie.

"Better," she muttered.

The shuttle entrance peeled open and light poured in. The Jenregar scout rose from a mound of material about even with an average Human adult's knees. It had enfolded the scout within it, and now seemed to melt down until the floor was level.

Mike scrambled to his feet, Natalie right behind him. They had to get through that doorway before it folded closed. They slipped through the doorway just in time. Mike looked at his surroundings. . . .

And stopped cold. The Jenregar's version of a hangar bay was just big enough to hold three of its shuttles, a space about eight meters square. No large expanses, no observation decks. Instead, around the bay were perhaps a dozen tunnels made of that smooth, dark-red carapace material that seemed ubiquitous in both Jenregar biology and technology. A peek into those tunnels revealed uphill grades in some, downhill paths in others. Jenregar scouts, builders, and protectors, were as ever, on the move, as were other specialities Mike hadn't glimpsed before. The hangar deck was apparently one of the Jenregar starcraft's busiest hubs. All the Jenregar individuals ignored the hiding-in-plain-sight Humans.

A touch at Mike's shoulder made him

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jump, but it was Natalie. "Sorry," she said, and pointed to one of the tunnels to their right. "But our courier went that way."

"Glad you noticed," Mike said, then set out to catch up.

The courier had gone into an "uphill" corridor, about a thirty-degree grade, which made Mike confident that he and Natalie were headed toward some sort of command center. Unless that was too Human-centered a thought. No matter. This was the course he'd chosen, and they would stay on it until one of them had a better idea.

The tunnel's smooth reddish surface and steep grade meant Mike's feet slipped more than once on their way up. And he had to keep bent over so he wouldn't crack his head on the low ceiling. Add to that the necessity of dodging Jenregar coming the other way in the narrow shaft, and it was slower going than Mike would have wished. All that while keeping the courier in view.

They passed through another hub, one which housed some sort of Jenregar tech. Two individuals stood side-by-side, their fingers working at a console that seemed like a variation on the mound of material that had formed the courier's shuttle chair. Mike even glimpsed one of the Jenregar using his stinger on the surface of the console. Perhaps this particular adaptation emitted communication pheromones rather than poison or acid through the stinger. Another piece of evidence pointing toward Jenregar use of biotech.

Mike and Natalie traveled through two more hubs before the courier ahead of them finally entered an even narrower tunnel that was otherwise unoccupied. Mike ducked his head to follow. "This could be it," he told Natalie. "He could be getting close to the queen."

Behind him, Natalie's voice rang slightly in the tunnel's close quarters. "If there is a queen. Besides, no guards were posted."

"They wouldn't need guards. You can bet there's a pheromonic breeze at that entrance or that only certain Jenregar like this courier are hardwired to go here."

The two Humans were only a couple of steps behind the courier as the tunnel ended and they found themselves inside a compact chamber, four meters square and with the now-familiar mound at the center.

Atop that mound lay a Jenregar who was otherwise indistinguishable from any other they'd seen, a builder, judging from her yellow carapace. Her legs were folded beneath her and her boneless arms extended straight out before her, rather like a lioness lounging on the African veldt. A protector stood to either side. This had to be the Jenregar queen!

Mike's heart pounded as he was all too aware of just how far he was from any Human assistance, with the *Asaph Hall* ten K distant and maintaining radio silence, with this trip into the depths of the Jenregar ship having taken the better part of half an hour from the time they'd left Korolev Habitat's hangar bay, and knowing just how quickly a Jenregar stinger could maim or kill. Mike pulled his disruptor. Natalie silently did the same.

That's when the blue-backed protectors stepped forward, ignoring the courier but heading right for the two Humans.

"Uh oh," Mike said. "Guess we don't know the password." He raised his weapon but did not fire. A quick glance at Natalie's face and, seeing its mixture of concentration and fear, Mike realized he *should* have asked Linna along, her empathy invaluable in interpreting not the Jenregar's intention, but *Natalie's*. So far, though Natalie had raised her disruptor, she too, held her fire. She'd learned, apparently, since Anaktuvuk.

The courier was going about his business, oblivious to any other dramas occurring in the room. Mike split his attention between the advancing protectors

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and the courier, who was leaning over the queen and intertwining his left arm with her right.

But the protectors weren't stopping. No more time to study Jenregar communications theory. He pointed his disruptor at the nearer protector—

And switched his aim and shot the queen dead center. The courier jumped back as the queen's carapace flamed and she emitted a sharp scream in the half-second it took for her to die. That scream shot through Mike's nervous system like a lightning bolt. He'd looked down at supposed genocidal killer Natalie Kendall from some high moral ground and now, as a cold-blooded murderer, he'd toppled himself from that position.

Mike started to back away, but the protectors stopped, as if they were marionettes and Mike had severed their strings. They turned as one, then went over to the inert body of the queen. They picked up the remains and pushed past Mike and Natalie, headed through the tunnel to who-knew-where.

The courier kneeled and began cleaning the mound where the queen had rested. He used his hands to gather together left-behind chunks of the queen's carapace and the flesh still attached to it. He touched his stinger to the remains and acids dissolved them. He excreted fluids from beneath his arms to rinse the mound. Then he took position atop the mound and settled onto it.

"I don't believe it," Natalie said. "Our courier's become the queen."

Mike said, "They don't waste much time." Then, a chittering sound from the tunnel. "Protectors," Mike said. They were apparently replacements for the ones who had disappeared with the former queen's remains. They took their positions next to the new queen. Mike said, "It looks like we can destroy queens all day long and they'll never run out. Let's get the hell out of here."

Back through the tunnel. Mike and Natalie didn't speak all the way back to the small Jenregar shuttle bay. They stood amid the now-accustomed ebb and flow of Jenregar individuals for about ten minutes before a courier made his way toward a shuttle and the two Humans followed.

This time they knew to get quickly back to the rear of the shuttle to brace against the coming acceleration. In the moments before the shuttle boosted, Natalie asked Mike, "You see how easy it is?"

Mike looked straight ahead. "It was self-defense. I was about to shoot the protectors, but I thought if we were about to die I'd better make that shot count. So I went for the queen."

"I wasn't talking about the shot. You said 'destroy.' We could destroy queens all day and they wouldn't run out. You 'destroy' a *thing*, not anyone sentient."

Any response Mike might have made was crushed out of him as the Jenregar shuttle boosted toward Korolev Habitat.

Mike barely registered the Jenregar shuttle's docking. He didn't speak as he and Natalie followed the courier out into the habitat's southern docking bay. Mike couldn't help but notice that in barely an hour since they'd left, the bay was starting to look cramped as the Jenregar workers continued their work of dismantling Human artifacts to create a Jenregar nest.

Then, down the lift to the habitat floor, to make the journey back to the northern cap. Mike was amazed at the difference their short time away had made. Already he and Natalie had to make their way in the now-familiar crouching stance through tunnels similar to those on the Jenregar starcraft. Builders swarmed everywhere, transforming a Human habitat into a Jenregar environment.

It was difficult now for Mike to judge how far they'd come. After half an hour's walk, he had to wonder whether the Jenregar had advanced further into Human territory.

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Natalie broke the long silence that had fallen between them. "What if we're the only Humans left alive here?"

"Don't say that. It hasn't been that long. And the Unity will have cruisers here within days. Maybe hours."

Natalie muttered, "So we have to hope the Jenregar doesn't have something up its collective sleeve that can take on military starcraft."

Mike ducked his head to avoid an even-lower ceiling. "I was about to say it couldn't have anything like that, since it depends so little on sight. How would it target another ship? But it did find this habitat. It has stardrive, and obviously navigates its craft somehow."

Natalie said, in a voice that was not unkind, "We went there to find out more about the Jenregar. We did. We have more to work with now."

"Yeah. More. Such as how it's impossible to cripple the Jenregar leadership. How even if we *had* smuggled a bomb on board and destroyed the Jenregar starcraft, that probably would have just caused the scouts inside the habitat to operate more independently. They couldn't rely on messages from the mother ship, so they *wouldn't* have. We don't even know that was the queen's chambers."

"It had to be. If not the queen, at least an assistant. Though if an assistant is replaced that quickly, then the queen—"

"I don't want to talk any more about the queen. I killed her. For nothing."

"For self-defense. And if we still have you, the Humans on this habitat still have a chance. I'm sorry I . . . spoke to you the way I did earlier."

Mike stopped and let Jenregar builders and protectors squeeze past them. "Thank you."

"I remember you'd always tell people you're not a 'religionist.' I guess that means you don't know any saints. I don't either."

Mike looked at Natalie and nodded. "Let's keep going. Maybe save some lives for a change."

About twenty-five minutes later, they saw an end to the maze of tunnels they'd been traversing. Mike hadn't said anything to Natalie, but he'd been afraid they'd gotten lost in a Jenregar labyrinth. As they exited the tunnel, Mike stretched, grateful not to have to walk at a stoop any longer. He took in their surroundings, and said, "It's taken more ground." The Jenregar tunnels were well-established around Korolev Habitat's entire southern circumference, and over a third of the way toward the northern cap, with construction visibly continuing about two-thirds of the way across.

Natalie said, "We're past the command-post position. Now where the hell do we go?"

A flashing light at the edge of a Human-controlled parkland nearly directly overhead caught Mike's eye. He could see people gathering there. He pointed them out to Natalie. "What are they doing?"

Natalie said, "A new command post, maybe?"

Mike looked across the .2 kilometer distance. "They're . . . forming groups. Wait a minute. They're making letters!"

"A message?"

"Looks like. Leave it to Georges to find a way to communicate during radio silence." The Humans inside the parkland arranged themselves to spell out:

MIKE NAT
HERF

Mike tilted his head to one side, without advancing his understanding. "I guess you're 'NAT,' but 'HERF'?"

"They're saying, 'HERE'!" Natalie exclaimed. "They must've run out of people."

"Then let's get there," Mike said, and he and Natalie started that way. Within fifteen minutes they'd made their way around the habitat's interior and through a Human checkpoint.

They found Linna, Rishona, and Georges not at a command post but, to

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Mike's disbelief, an evacuation center in the broad parkland where habitat residents had gathered to deliver their long-distance message. The place looked eerily like the interior of the Jenregar ship, as scores of individuals darted off in one direction or another in pursuit of their various duties or errands.

After greetings and hugs all around, Georges confirmed that, indeed, he was the one who'd thought of gathering people together to deliver the message. "It's too bad," Georges said, "that we haven't had more time to find out as much as we could about these beings."

At a look from Mike, Linna explained, "The Unity has requested the *Hall* to take as many people off the habitat as it can."

Rishona said, "And the first Unity cruisers have orders not to engage the Jenregar if it will allow them to evacuate everyone else."

Mike asked, "So we're just giving up?"

Georges' expression was kind but unwavering. "We'd hoped you and Natalie could find the queen and disable them all. But the analogy we'd made with ants wasn't close enough. From your description, they've evolved to prevent an outside entity from disrupting their command structure."

Mike put a finger to his lips. Another idea had occurred to him . . . "How soon until the evacuation begins?"

Linna said, "Six hours."

"And then I know exactly what will happen. Those cruisers' commander will insist that we either abandon the habitat to the Jenregar or destroy it, and the Jenregar with it. Either path reduces Unity casualties."

Rishona tilted her head in mild reproach. "You can't blame them for that, Mike."

"I don't. But we also have to look at what might happen the next time the Jenregar and Humanity make contact. We have more freedom of action than it does. And we can perceive things it cannot. Its focus is too narrow—survival only. If our actions can make it understand that there's no survival value in dealing with Humanity, we may have a chance."

Georges asked, "How do we turn all that into an advantage?"

"You notice how quickly it replaced the queen I . . . killed. Any other course would have meant chaos. Its life is ordered. We have to find a way to sow some disorder."

Natalie said, "We tried that, but they replaced the queen right away."

"Yes, but we also witnessed something that I just realized is more important. Georges and Rishona, if the two of you can look at the pheromone samples Natalie and I took on the Jenregar ship, I think we may have a literal solution to our problem."

Five and a half hours later, the Jenregar had pushed to within a quarter-kilometer of Korolev Habitat's northern cap. Even in such a drastically-reduced area, it still wasn't terribly crowded for the nearly five thousand Humans giving way before their invaders. But, as Linna told Mike there in the middle of the parkland as Natalie, Georges and Rishona set up a makeshift spray device, "Everyone's feeling squeezed. They've been worried all this time, of course, but they've also been hopeful. That's going away. I'm reading despair. The first signs of panic. I'm as worried about getting everyone evacuated without a riot as I am about the Jenregar."

Mike rubbed his chin to play for time and work to keep a nervous edge out of his voice. "I'm not ready to give up hope myself. But that doesn't mean we can't fail. If you could work with the evacuation crews and pinpoint anyone who's about to cause a problem—"

"Mike, there are five thousand people here. I can't be near all of them at once." Linna could only detect emotional radiation to a distance of about four meters.

"Still, you can help. Get up to the northern hub. Everyone has to pass

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through there to get off the habitat. If there's going to be a flashpoint, that's likely to be it, where people can see their way out and get desperate."

"I'll get right there," Linna said, and left.

Mike returned his attention to his other colleagues and their sprayer, which was a three-meter long tube mounted on a tripedal swivel stand. They had pulled it out of an irrigation array just minutes earlier and attached a sealed container filled with a synthesized concentrate Mike had dubbed the "undertaker" pheromone. "Well?"

Georges looked up at him. "We're ready," he said, and Rishona and Natalie nodded agreement.

They didn't waste any time. It was take their new weapon to the Jenregar or wait to be overrun. To the edge of the parkland, then, against the flow of Humanity headed away from the Jenregar.

The four of them neared a line of security officers preparing for another retreat. They formed a line about a dozen meters behind a four-meter-tall force shield. Mike knew how frustrating it was to keep pulling back toward the northern cap, relinquishing home turf meter by meter.

Watching the shimmering translucent shield, seeing the Jenregar in turn forming up in ranks behind it, Mike wondered why the species didn't seem to have developed flight technology. The simplest glider would take them easily over the simple shields the Humans had mustered. Establishing an energy "roof" over broad areas would have strained the habitat's energy resources to the max.

So how had such beings ever become starfarers? Could there be other intelligence at work deeper within Jenregar society, an intelligence he and Natalie had missed? Or could all the Jenregar be working for yet another Galactic species, one that had brought them into space?

No time to worry about that now. Mike found the officer in charge of the small contingent of security officers, introduced himself, and convinced the man, a Lt. Neal Logan, to allow them to set up their sprayer. "Go ahead," Logan said. "We've got a few more moments' prep ourselves." His officers were following a standard retreat gambit: fall back from the shield the Jenregar were about to puncture, set up another that used a different frequency, then try to hold that line a few more minutes or hours. Sometimes the Jenregar burst through the first shield before the second one could be set up, though, and that's when all hell would break loose.

Mike explained to Logan, "I'd like you to delay that second shield after you bring down the first. By just about a second."

Logan's chin raised a notch. "That's *all* you'll get. Sir."

"Just let me know about two seconds before you let that shield down. We'll start the spray right then."

Logan said, "I'd say we'd best get right to it, sir." He held a palm control at the ready and said, "Two seconds after you begin your spray, then."

Mike turned to Rishona, whose finger was on the sprayer's main control. Georges stood at the rear, ready to fine-tune the device's aim. "Begin spray," Mike said.

Rishona hit the button, and a narrow stream of yellowish fluid shot out under pressure, landing just short of the shield. Then Logan killed the shield.

Over a dozen Jenregar scouts burst forth, silent as always, no whoops or cries needed to stir emotions they did not possess. The four in the lead strode right into the spray.

And stopped cold, as if perplexed.

Those behind them stopped, too, but only for an instant. Now they had a new purpose. Four of the remaining scouts grasped those dripping with the special concentrate and retreated with their squirming bodies. Georges raised his aim a bit and splashed the rest, who fell

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all over one another trying to take each other behind the lines for disposal.

Rishona stopped the spray and looked up at Mike, who said, "Let's get the replicators working. And delay the evacuation."

Replicators hummed, creating liter upon liter of the undertaker pheromone. Vents blew the substance into as much of the habitat's interior as Humans still controlled. Over the next few hours, that area grew larger as the Jenregar retreated, if individuals attempting desperately to dispose of one another's still-living bodies could be called a retreat.

Mike quickly hit upon an effective tactic—aim the spray in one area while leaving an adjacent one untouched. That left many Jenregar individuals unaffected, and they quickly devoted themselves to laborious attempts to dispose of their colleagues, abandoning whole neighborhoods in the process.

Within three hours, some overriding protocol must have kicked in among the Jenregar, as all its scouts, builders, and protectors retreated toward the Korolev habitat's southern cap, entered shuttles, and returned to their starcraft. That craft, in turn, flashed out of the system minutes later. By the time the Earth Unity cruisers arrived, their mission was obsolete.

The next day, Mike, Linna, Georges, and Rishona stood before Natalie's house. The Jenregar had trashed the place. Natalie, Ralph, and Duncan stepped carefully through the structure looking for belongings to salvage. Part of the one-story structure had been dismantled to create the beginnings of a Jenregar nest that covered the area where the small pond had been. The lawn had been stripped away, so that Mike and the others were walking on topsoil.

Natalie picked up an object small enough to cup in her palm. She left her home's wreckage and walked over to the *Asaph Hall* crewmembers. Ralph was right behind her, waving for Duncan to join them.

Natalie smiled at Mike and the others and held up a holocube between thumb and index finger. "Wedding pictures." She looked at Ralph and the smile grew crooked. "And there's a subset program, too."

Ralph muttered, "*Nat.* . . ."

Natalie's voice went low. "A duplicate of *me.* Complete with tactile response protocols. Double the fun, you might say."

Mike had never seen a man as swarthy as Ralph turn so red. Everyone laughed, then it was time for goodbyes all around. Mike lingered as Linna, Georges, and Rishona began their walk toward the northern cap, where the shuttles *Phobos 2* and *Cosmic Egg* would return them to the *Asaph Hall.*

Ralph and Duncan headed back toward the ruins of their home. Ralph looked over his shoulder. "Coming, Nat?"

Natalie said, "In a minute." In the instant before Ralph turned away, Mike saw the man's embarrassment had faded, and his expression revealed wonderment and perhaps even suspicion. He could imagine Ralph's thoughts about him: who was this man from his wife's past, who seemed to share something with her that she'd not revealed to him?

Natalie watched as husband and child started sifting through the rubble again. "I love them more than I can say. I don't want to hurt them." She looked at Mike.

He said, "I'm not going to tell them what happened. On Anaktuvuk."

"I appreciate that."

Mike shook his head. "Don't thank me. I'm filing a report with the Unity."

"But that means—"

"It means you need to have a serious talk with Ralph. Soon. Especially since you're mayor now. This will get out quickly after I report in. He needs to hear about this from *you.*"

Natalie bowed her head. "I owe you

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that much."

"You don't owe me anything. We both owe Susanna Donsa and Fletcher Merryweather. And everyone on this habitat who was killed or hurt, or lost a home."

Natalie glanced at her own ruined house. "I guess I owe Duncan the most."

Mike looked at Natalie. "The truth. And a chance for Humanity to meet the Jenregar on more even terms."

Natalie's face lost all expression. "I have to help them with the house."

Mike said, "We're still friends."

Natalie embraced Mike. Her voice was nearly breathless, its tone even. "I'll talk to them."

Mike stepped back from Natalie and mustered his best smile. She turned toward her ravaged house.

Mike waved a farewell to Natalie's husband and son. Ralph raised his hand high, fingers outspread. Duncan flashed a beaming smile and waved stiff-armed, like a metronome gone wild.■

(Editor's Note: Mike Christopher has previously appeared in "Splendor's Laws" [June 2000].)

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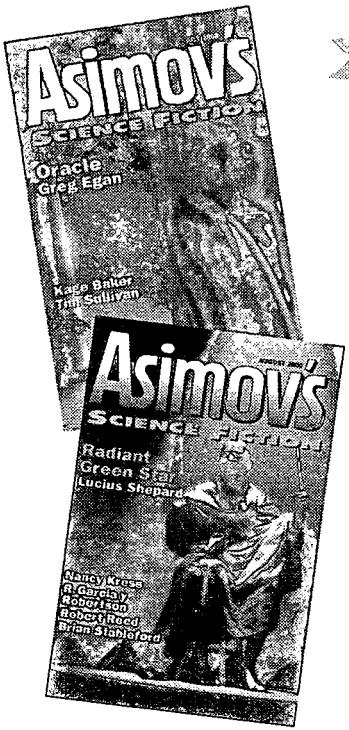

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Interstellar Navigation or Getting Where You Want to Go and Back Again (In One Piece)

John G. Hemry

Introduction

Traveling to another star system involves two fundamental problems. Problem Number One is how to go fast enough to make the journey practical in terms of human life-span, or alternatively how to design a ship capable of traveling for centuries of real-time. That tends to be the problem Science Fiction writers (and scientists) focus on.

But there's also Problem Number Two. How do you actually get to that other star and back home again? This question is usually covered by a vague reference to 'navigation', but it's actually a very complicated problem. Throw in concerns about obstacles to safe navigation and you've got some major monkey wrenches to deal with if we ever want to actually travel to another star.

Navigational Basics: Piloting

A look at navigation on the Earth's surface is a good way to provide a context for interstellar navigation. Specifically, this section will discuss navigation on water, because that is where methods of navigation developed and because aeronautical navigation uses essentially the same tools as surface navigation. Until the recent advent of the satellite-based Global Positioning System (GPS) (described in detail in William Walling's *YOU ARE HERE!* in the October, 1999 *Analog*), finding your way around the Earth was often a matter of educated guesses. Over millennia of exploration and travel, humans developed two basic forms of navigation.

One is called piloting, under which you receive frequent external input to your position. Prior to GPS, the most accurate form of piloting involved taking compass bearings to objects on the shore for which the exact positions are known, then extending those lines of bearing from the positions of the objects on your chart. Where the lines of bearing intersect is where you are (or rather, where you were when you shot the lines of bearing). Ideally, the lines of bearing meet in a single pinpoint, but in practice they tend to form polygons of varying sizes which define the area inside which your position lies. This is es-

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pecially true if you have to use other (less precise) means of piloting, such as radar. With radar, you determine the range to prominent points of land, then swing an arc out on your chart which is that distance from the point. You should lie somewhere along that arc, though this is less accurate than using lines of bearing because you can't always be sure exactly where your radar signal is bouncing off the point of land you are using.

Piloting is the form of navigation of choice, but you can still get in trouble in a variety of ways, such as misidentifying the objects you are shooting lines of bearing from, or taking position fixes too infrequently, or simply moving too fast so your fixes come too late to prevent danger.

Navigational Basics: Dead Reckoning, Celestial, and Remote Signals

Nice as it is, piloting often cannot be used. If you can't see something to take your bearings from, you can't pilot. That's true in fog or other conditions of limited visibility, at night off a shoreline without lighted navigational references, or just out of sight or radar range of land. Then you have to fall back on the second form of navigation, which is called Dead Reckoning (DR). DR uses simple physics to estimate your location: if you travel at a certain velocity for a certain period of time, you will cover a certain distance. Unfortunately, the "dead" part of DR refers to the fact that you have no means of accounting for internal and external errors. Internal errors include things like your engines not pushing the ship at exactly the speed they're supposed to, or a helm who tends to steer just a little to starboard of the ordered course. External errors are summarized as "wind and wave," the environmental factors which push your ship around in unpredictable ways and alter your actual speed over ground and your course made good (that is, the course you actually followed, as opposed to the course you tried to follow). Even small errors build up over enough time and distance. Stronger winds and waves (or poor steering) can build up large errors very rapidly. That's why you're never supposed to use DR in a restricted navigational situation (such as near reefs, or in a harbor).

To help overcome the limitations of DR, other means of fixing positions were developed. Until relatively recently, these were based on observations of celestial objects by essentially working a backwards process. The Earth was divided into a grid of latitude and longitude, then legions of bleary-eyed mathematicians filled tables with computations showing just where the brightest stars and planets should appear to be if you were looking at them from points all over that grid. To get a celestial fix you first use DR to estimate where you think you are, then consult the celestial tables to see which stars should be visible and about where they should be. You also have to know the *exact* time of your observations. You then take sights on the individual stars, using a sextant to determine the angle of elevation between the sea-level horizon and each star. Note that you aren't shooting a bearing to the star, but are measuring how high it is above the horizon. (To do this, you need both a clearly visible horizon and visible stars, meaning you have to do celestial observations at morning or evening twilight.) The stars in the celestial navigation tables are chosen because their luminosity and locations make them fairly easy to spot, which is why navigators know how to pronounce Betelgeuse.

With the observed elevation of a star in hand, you can then calculate a position line (if you are seeing that star at that elevation above the horizon on that specific date and time, you should be somewhere along that position line on the surface of our planet). Several star shots yield several such lines, which

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hopefully intersect on your chart in something resembling a small polygon, thereby placing you somewhere inside that polygon. In practice, the polygons can be pretty darn large, especially if your observation lines end up running close to parallel instead of at large angles to each other. Clumsy, time-consuming and barely accurate as the whole process is, it is still far better than depending on DR for your position.

You can also shoot the Sun, getting running lines of bearing at such times as Local Apparent Noon (again, telling you along which line you should be if you see the Sun maximize its altitude in the sky at a certain time). By working various calculations, you can use a number of sun lines to estimate your position.

It's all tremendously complicated, requiring immense effort to keep the celestial tables updated, not to mention the effort needed to calculate the tables in the first place. None of it worked well enough, either, until technology advanced far enough to build very accurate chronometers so the exact time of a star observation could be known. But sailors used it because it was a whole lot better than nothing, and accurate navigation has been critical to seagoing exploration, trade, and warfare. This is true because, quite apart from the basic problem of knowing where you are, navigation is also used to determine where something else is located. That "something else" might be a deadly reef, or a safe harbor.

Technology eventually came up with other ways to get positional updates. Ground-based broadcast positioning systems such as Loran and Omega provided partial coverage of the Earth by transmitting signals from fixed sites. If you were within the transmitters' area of coverage, a receiver would analyze the signals from different transmitters, coming up with a location based on signal variations. Later, the first satellite navigational systems came on line, providing better coverage and accuracy, though with availability limited by when satellites were passing overhead. Eventually, GPS has given us extremely accurate positional data at any time of day anywhere on the globe. In a sense, we've satisfied the fondest dream of navigators, since GPS is essentially an always available, highly accurate piloting system, using differences in the signals received from different satellites to continuously calculate where you are relative to them.

Using Known Navigational Methods in Deep Space

Unfortunately, the downside of GPS is that it is so easy, people are likely to quickly forget how hard it is to locate yourself if you don't have multiple constellations of satellites in predictable orbits. GPS won't work off the Earth, and there is no currently imaginable means of replicating GPS-like coverage outside the solar system.

What happens when we leave the Earth's surface and go into deep space? Obviously, we're no longer dealing with finding our position on or near the surface of a globe. Instead, we're concerned with locating where we are inside the volume of a much, much larger globe. And where we are inside that volume changes where everything appears to be.

Two big complicating factors to simple piloting in interstellar space are that everything is moving and nothing is where it appears to be. The Earth moves around the Sun, the Sun moves through our Galaxy, and our Galaxy moves through the Universe. Everything else in the Universe is also moving along its own path. As a rule, navigators on Earth haven't had to worry about both their destination and their starting point moving independently. So in deep space your problem isn't simply to go to a fixed location, but to work out an intercept course with a moving object, and then an intercept course back to where your home will be.

Neither of which are where they

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seem. Due to light-speed limitations, we see stars where they were when their light started its journey toward us. As we move through space, the length of that journey alters, so we see the stars at different locations. If we instantaneously jumped a light-year distant from Earth, we would see the stars in locations based on how long their light took to reach *that* point. It still wouldn't be where the stars are actually located, of course.

This produces a very complex navigational problem. The objects from which you want to take bearings are moving, and their apparent locations shift as you move. In order to use bearings from stars to fix your position in space, you would need to precalculate the apparent locations of stars at certain times for a vast number of points inside an incredibly huge sphere of space. The resulting "fix" wouldn't be the two-dimensional polygon familiar on Earth, but a three-dimensional box with vague measurements. The navigational problem isn't inherently unsolvable, but it is tremendously difficult.

Where exactly are the stars, anyway? Measurements of stellar distance are estimates based primarily on luminosity. It's hardly precise, but it's the best we can do, and it doesn't matter much to an astronomer whether a star is actually a trillion kilometers further away than the 'fifty light-years' used to designate its distance. But it makes a big difference if you are actually trying to go there, or trying to get a precise fix on your location. The closer you get to a star, the more errors would be introduced by differences in its actual position relative to where we think it is.

Why not just use DR and adjust course whenever you seem to be drifting? That could be done, though it would potentially produce a long stern chase (imagine trying to reach Mars that way; you might be chasing the planet around its orbit for a long time). There's a variety of ways to conduct an intercept, depending on your position relative to the target and your ability to accelerate and maintain speed. Still, you would be certain to succeed if you follow the old mantra of "constant bearing, decreasing range." Any object which fits those criteria is going to hit you (or you're going to hit it). It would work as long as you could see your target.

Which is the problem. Get close enough to the speed of light and your vision of the outside world gets weird. Where is your target in that clustered mass ahead of the ship? How do you aim for something you can't see?

Assuming faster-than-light (FTL) travel proves feasible at some point, it will create a similar difficulty. FTL may never be possible, and if it does prove possible, it will use physical principles we can only guess at today. Still, whatever picture the rest of the Universe presents during FTL, it's highly unlikely to be easily recognizable.

So, if you want to use a form of celestial navigation in your near-light velocity or FTL ship, even if only to see where your objective appears to be, you'll have to drop down to much slower speeds in order to look around. Finding out where you are will require almost stopping in order to "ask directions" of the Universe. Since acceleration and deceleration are no small issue for interstellar travel, that's a major concern.

Alternatively, it may be possible to use a system to compensate for relativistic distortion and eliminate the need to slow down for bearings. There is one basic problem with this concept; in order to accurately compensate for relativistic distortion, you need to know exactly how fast you are going. Whatever system is handling the compensation for relativistic distortion is going to take its input of ship's speed and apply it to compensating the external view. Yet if actual speed is not the same as the speed the system uses to compensate, the resulting picture would put the stars in slightly wrong positions. If you sped

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up/slowed down based on those positions, the errors would compound. In the end, it would come down to the questions of how much you trusted the technology which propelled the ship to predictably accelerate and maintain an exact speed, how much you trusted the relativistic compensator to produce an accurate external picture, and how much resultant error you were willing or able to accept in your ship's position. It could be that for 'short' runs of, say, five or ten light-years, the errors would be within acceptable parameters, while longer voyages would require slowdowns to attempt to check your actual position against your systems' estimated position.

There's another big joker in the cosmic deck, too. As noted before, calculating a position accurately on the surface of the Earth ultimately required the invention of chronometers which would remain very accurate for long periods, because you needed to know exactly what time it was in order to do all those calculations about where the stars ought to be when. So, there you are, zooming through space close to the speed of light, or in your alternate frame of reference at velocities exceeding the speed of light, and you return to normal space to look around and find out where you are by seeing where the stars appear to be, taking into account your estimated location and the precise time. But *what time is it?* Do you have a chronometer on your ship which corrects for whatever time distortion is caused by near-light velocities? Since the exact amount of time distortion is a function of your exact speed, calculating the precise time would require knowing exactly how fast you're going. But if you knew that you wouldn't be trying to find out where you were. It's a nasty little circular problem, and its successful solution may require the same sort of effort and technological breakthroughs that eventually solved the longitude location problem on Earth. An FTL drive, of course, could drastically alter perceptions of time in ways we can't predict now, and so cannot begin to work at countering.

Making it Work

Despite these considerations, can we successfully navigate through interstellar space? Will DR work well enough in an interstellar environment? The answer depends partly on the nature of your machinery. Maintaining absolutely constant acceleration and velocity would allow a ship to know exactly how much distance it had covered, and if your guidance system can flawlessly correct for every deviation in course, you can at least count on going where you think you're going, whether or not the star you're aiming for is actually there. Unfortunately, humanity hasn't had a lot of success so far with producing machinery that flawless.

The imperfect solution to this problem may well be an ancient one. Someone who has served for a long time on a specific (surface) ship learns the quirks of its machinery, as much by instinct as calculation. Over time, rules-of-thumb develop for how different actual speed will be from speed ordered, and what kind of errors consistently crop up in the steering system. An experienced captain should know what his or her ship will do under a variety of conditions. The same principles should apply to spaceships, meaning we would need to assign permanent crews (who could learn the quirks of their systems) to deep-space ships, instead of the aircraft-like rotating crew system currently used for the space shuttles. Interestingly, by some instinct of their own, SF writers have tended to assume spaceship crews would be analogous to surface ship crews, learning their ships inside and out through years of experience. This doesn't eliminate the problem of mechanical errors, but it does mitigate it.

However, there are still environmental effects. There's no wind or wave in space, but there is gravity. Gravity bends

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light. How will it impact on something traveling at close to light speed? It wouldn't take much. A deviation of a tiny fraction of a degree in your course caused by a large gravity well would translate to a very large error over a path of fifty light years. Since the ship is likely to pass numerous gravity wells of varying strength over the length of a multi-light year journey, predicting the impact on your course could be fairly complex. That assumes you know all the significant gravitational sources along your route, not just the highly visible sources.

If there is no way to be sure exactly how fast you've gone, exactly which direction you've traveled, and you can't use the available navigational references to fix your position precisely, then an exact position in interstellar space may be an oxymoron. Estimated positions may be the accepted standard for want of anything better. Again, this is not unprecedented. Until very recently, exact positions of ships were often unknown. For example, despite the length of time it took the *Titanic* to sink and all the ships which were in its area and responded to its SOS, it required long and tedious searches to finally find the wreck. Where open ocean positions could easily be off by dozens of miles (or more) prior to the advent of GPS, interstellar ship positions may have to accept errors of literally millions of kilometers. This won't be because people are happy with the imprecision, but because no better accuracy will be possible outside of solar systems.

Given that we can't know exactly where we are in interstellar space, how can we successfully reach another star, let alone establish regular traffic between stars? Again, the potential solution is an ancient one. In the days when sailing ships were exploring the planet and trying to establish trade routes, 'sailing directions' were developed by the tedious and often dangerous method of looking for something until you found it, carefully recording just how far and how long each stage of the journey took, and any special landmarks or hazards along the way. Given the previously noted problems with observing an objective at near-light or trans-light speeds, odds are that reaching another star would be a multi-stage process. After a long run, the ship would slow down enough to eliminate relativistic distortions, then figure out roughly where it was and examine the nearest stars to identify which one it was aiming for. Then the ship would accelerate towards its goal, slow down when the crew thinks it is close, check position again, and repeat until you finally reach your objective. All of which would be tedious, but not inherently impossible. Such multiple starting and stopping would, however, have a significant impact on fuel supply requirements and the time ("real" and "relative") a voyage would require.

So, assuming the initial problems of localizing another star are successfully overcome and a ship has actually made it there, that ship could put together sailing directions which other ships could use to also reach the same star. At that point, traveling back and forth to that star could be fairly routine. Interstellar spaceships would simply follow directions mandating certain velocities for certain periods of time, hoping any internal and external variations produce a small enough cumulative error to allow a planned-for 'starfall' (*vice* landfall). Unfortunately, any major errors in course or speed could result in a ship ending up lost somewhere far from where the rigid sailing directions dictate. Getting to safety in that case would be a matter of hoping fuel supplies and environmental systems would last long enough to feel your way home.

Of course, sailing directions would have to be constantly updated to correct for predictable celestial movements. Movement of intervening environmental hazards, such as gravity wells, would of course alter their effect on a ship's course and speed and introduce new er-

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rors. Again, theoretically, you could chart all these hazards and calculate how to correct for their influences, but marking their exact positions in interstellar space would be a major undertaking. What exactly do you reference to specify where a hazard is located in interstellar space?

In addition, all of this data isn't necessarily going to be made available to anyone who asks. In Earth's history, sailing directions to important places were often kept secret by companies or governments eager to maintain commercial advantage. If space exploration is privatized, it's not hard to imagine scientists seething with frustration as the Tau Ceti Company refuses to disclose "proprietary information" about the star (including how to get there).

So interstellar navigation isn't a matter of following a simple roadmap. It's going to be a very difficult problem to overcome, but because in-system navigation is relatively easy (due to our ability to plant navigational beacons and spacecraft velocities which don't cause visual or time distortions), it may not surface until after we've solved all the other problems of interstellar travel. Our first interstellar travelers might find themselves wandering around trying to find out exactly where they are, and (most importantly), exactly how to get home again.

Hazards to Safe Navigation

That is, if our interstellar voyagers survive, because in the field of navigation there's also rocks and shoals. As noted above, one of the most critical uses of terrestrial navigation has been fixing the locations of dangerous objects so no one would hit them. We don't know how serious this problem will be in interstellar navigation. We do know that every part of "empty" space we've been able to closely examine is full of rocks and dust. Even if those rocks and dust are only present in large quantities around solar systems, that still creates a big problem because those systems are where we want to go. How do we find and fix all the rocks along a light-years-long potential route to another star, especially given that all the rocks and stars in the Universe are in constant movement? The rocks don't have to be big. Impacting a fist-sized object at a relative velocity of almost twice the speed of light, or even .95 of the speed of light, would no doubt be a spectacular event (though in the case of an FTL drive, the extent of this hazard would depend on the nature of the physics which make it work).

The traditional seafaring method of avoiding hazards is to post lookouts whose job is to spot trouble coming in time for the ship to take necessary evasive action. Often this simple system works. Sometimes it doesn't, as when the *Titanic* hit an iceberg because the ship was traveling too fast to evade the oncoming object. When radar came along, it was quickly adopted for navigational safety, as radar can see farther and more accurately than any human lookout. Radar (Radio Detection and Ranging) works by sending out an energy pulse. If the pulse encounters an object, part of that energy is reflected back to the source, where it can be analyzed to provide the range and bearing of the object. Radar isn't foolproof, but it helps ensure that any ship which runs into something does so by inattention rather than inability to predict danger.

Unfortunately, radar would be of minimal help on a ship traveling close to the speed of light and no help at all on an FTL ship. That's because the radar pulse travels at the speed of light. If you're traveling faster than light, you're also traveling faster than any radar pulse. Even at sublight speeds, velocities close to the speed of light would mean the radar pulse would have little chance of detecting an object ahead before you were on top of it. Like the *Titanic*, your speed would ensure there was no chance of avoiding a collision, no chance of overcoming momentum to

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turn your ship away from the hazard in time.

That hazard could be another ship. You might think the odds of two interstellar spaceships colliding are infinitesimal given the sheer volume of space. They're not. Just as seagoing ships (and aircraft) tend to blunder into each other, so will interstellar spaceships, and for the same reason. Ships tend to be going to the same places, along the same routes. It doesn't matter how big the oceans are or how big space is. What matters is how small an area the ships end up transiting on their way to the places they want to go. That's why you hear of crowded shipping lanes on Earth.

If a means to detect oncoming objects at faster than the speed of light is critical to safe near-light-speed or FTL navigation, then after accomplishing the astounding feat of figuring out how to accelerate a ship to near-light or FTL velocities, scientists will have to figure out how to accelerate something else to even higher velocities so that the something else can be projected ahead to bounce back from objects in the ship's path and provide hazard detection and warning (perhaps Tachyon Detection and Ranging (TADAR)?). Interstellar ship speeds may end up being limited not by the physics of their propulsion drives, but by the need to travel slow enough so that their detection systems can spot danger in time for avoidance maneuvers.

In theory, at least, sufficiently powerful magnetic fields could shove aside objects before impact. FTL and near-light velocity spaceships may require such magnetic field systems to survive. However, even the strongest magnetic field isn't going to shove something out of the way in time at speeds close to or exceeding the velocity of light. Moreover, even the most powerful field would have trouble if it encountered a stray planet in the ship's path. In addition, the size and power requirements of such fields might well be so huge that they demand the bulk of the spaceship's capabilities, leaving little room for passengers or cargo.

We've actually already faced and solved this problem on Earth, too. In the end, the only practical solution may be to use special ships equipped with extremely powerful fields to sweep tunnels through space which would be free of obstacles. Such rockbreakers would fulfill the same function as icebreakers on Earth, clearing travel lanes for commerce. Since everything is moving, the rockbreaker task would be never-ending, sweeping adjusted tunnels as stars move at either end and obstacles drift into the tunnels. Major hazards would have to be tagged and tracked just as icebergs are on Earth's oceans. Nearer to star systems, safe paths would be 'dredged' by other ships designed to clear obstacles from near-system and in-system transit lanes.

It is likely than any such rockbreakers and space dredges would have to travel significantly slower than the speed of light in order to do their job. That means opening a new shipping route would be a very time-consuming process. If the potential profits are high enough, however, mankind has proved willing to invest the necessary effort.

None of these problems with navigation or shipping hazards ever stopped the flow of sea-based travel and commerce on Earth, even though position errors and obstacles such as reefs have inflicted staggering losses on ships throughout the course of human history. Even as humanity devoted great efforts to solving the problems of safe and precise navigation, the ships and sailors kept going out because exploration, economic, and national security concerns all outweighed the losses. In the future, interstellar trade will be driven by similar pressures. Our ability to solve the problems of navigation in interstellar space will determine how many ships we lose as the price of exploration, commerce and defense. ■

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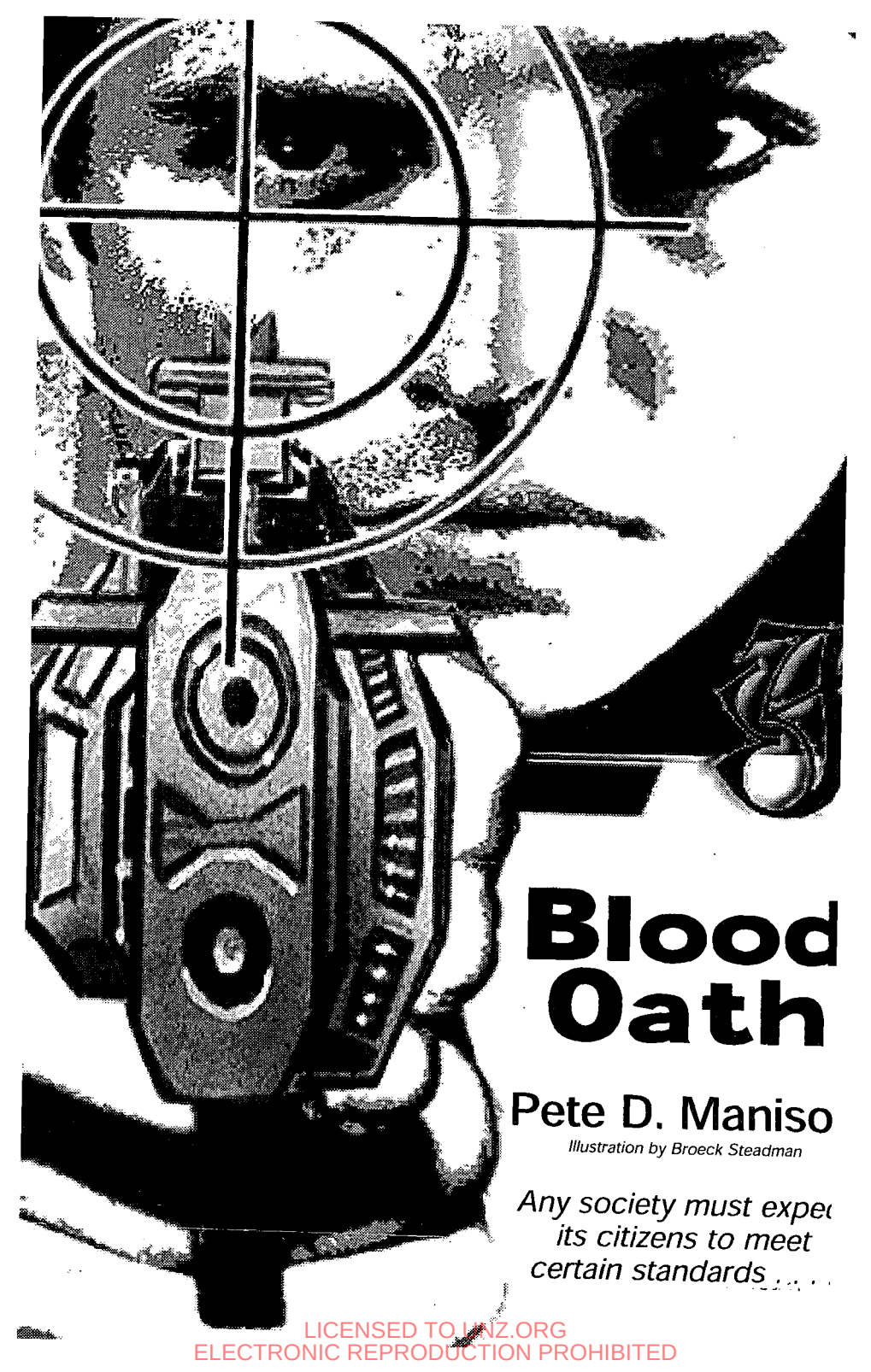

Blood Oath

Pete D. Maniso

Illustration by Broeck Steadman

Any society must expe
its citizens to meet
certain standards . . .

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The prisoners from Earth were brought into the assembly hall toward the end of the ceremony. Beyond the transparent barrier, they squinted in the harsh lights, confused and apprehensive. More than fifty prospective citizens had taken the oath of allegiance to Ceres Prime, and now it was time for the final act, which would prove their loyalty to the colony, without which they would face deportation to Earth.

Miharu Yamanaka watched from the gallery. Ten years as a caseworker for the Office of Immigration and Naturalization had never made this moment any easier to witness. She attended the ceremony seldom enough, with the strict compartmentalization of her department, but lately her supervisor, Hemani Losura, had insisted on it. The war, he said, had changed everything.

"Each of you was born on Earth," the administrator said, his amplified voice carrying to every corner of the auditorium. "That, in itself, is no crime. But the destruction of Juno and Psyche has demonstrated the ruthlessness of your former countrymen. Today you have renounced your allegiance to Earth in order to become citizens of Ceres Prime. There were times when a simple oath would have ended this ceremony. But blood calls for blood. Today you must prove your willingness to defend our nation against those who crave its destruction."

Nervous murmurings from the audience. Miharu looked at the many faces: brown, white, yellow, and black. With the ceremony closed to the public, these were all immigrants, all hopeful citizens. How many of them, she wondered, were here by choice, how many because the gravity well of Earth, after all these years, would kill them?

"As your name is called, please come forward and take your place at the barrier."

The administrator started with the A's, assigning each man or woman to a numbered station, where a fixed weapon sat waiting. The prisoners on the far side were shackled and blindfolded, each one situated before one of the guns. Moving by slow bounds in the minuscule gravity, the prospective citizens took their places. Miharu was surprised to see that of the fifty, only a handful remained in their seats, unwilling or unable to comply with this final requirement.

"Remember," said the administrator, "these prisoners are murderers. Each of them was captured in battle, caught in the attempt to destroy us."

One of the holdouts, a middle-aged woman, reluctantly rose to her feet and took her station. The others remained seated.

"Very well," said the administrator. "Those of you who decline please report to the Blue Room immediately after the ceremony."

None of them moved, though Miharu saw tears in their eyes.

"Prospective citizens, take your weapons!"

Miharu watched, fascinated, as they complied.

"Aim!"

She closed her eyes.

"Fire!"

The apartment said much about Miharu Yamanaka's newest assignment, #14121, Jalen Croft. Pictures from Earth adorned all four walls of the small room, views not of Mt. Everest or the Pyramids but of a small town in what looked like the United States, where simple dwellings in the foreground gave way to corn fields that swept to the horizon. Two faces showed up again and again in the photos: a man and a woman in their fifties, their smiles tinged by something—regret?

Miharu stood in the center of the room, feeling oddly intrusive. There were no locked doors on Ceres. With deportation the punishment for most crimes, people could come and go,

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leave their belongings unprotected, and in consequence the idea of knocking, of waiting to be let in, was as alien as the open blue sky in the many photographs.

Yet here she felt awkward, out of place. Was it because she had never met Jalen Croft face to face? Or was it that this room, with its mementos of a life left far behind, revealed too much of the person she had come to see?

On a small table stood an oblong plastic container. Miharu walked over and picked it up. Sand flowed inside the sealed container when she tilted it, each grain flashing in the light. A part of Earth, she thought. A reminder of home.

Vaguely disturbed, Miharu set down the container. According to the records, Jalen Croft had been a resident of Ceres for nine years. Ironic, considering that the cutoff was ten. One more year and none of this would be necessary: his citizenship would have been granted automatically. That wasn't what disturbed her, though. On the wall behind the table, a single hologram—the only one in the room—depicted the same two individuals who appeared so often in the photographs. The man and woman looked out, lifelike, from the three-dimensional projection, their eyes seeming to follow her as she moved. Something in those eyes, the unconditional love of parents, perhaps, reminded her of her own aloneness, of the fact that no one had ever looked at her with that bright affection in their faces.

The door opened. Miharu turned as the man stepped into the room, saw her, and stopped.

"Jalen Croft?" His blue coveralls were smeared with grease at the shoulder and across the midsection. His blond hair, cut short in the current style, framed a face whose bone structure was more reminiscent of the woman in the photos than the man.

"Yes," he said. "You must be Mrs. Yamanaka."

"Ms.," she corrected, bowing in greeting. He returned the bow, but his posture was stiff. Would he be like the others, fearful of the power he thought she held over him?

"I'm here on behalf of the Office of Immigration and Naturalization, Mr. Croft."

"Please, call me Jalen."

Miharu smiled, surprised. "Jalen. As I was saying, I have been assigned to your case to ease you through this transitional period. You're aware of the new deadline regarding your request for citizenship?"

"Would you like something to drink, Ms. Yamanaka? I have juice. Or perhaps a glass of milk."

Miharu felt her face go hot. No one had ever offered her a drink, not in all her interviews. "Water would be fine. And please, call me Miharu."

"That's a pretty name," Jalen said from the corner kitchenette. "Japanese?"

"I assume so. I was abandoned at birth. The records on my parents are sealed, so I'll never—" Thankfully, he returned just then with the water. "You are too kind," she said, accepting the glass.

"Not at all. You were saying—about the deadline?"

She took a sip of water. Cold, with a trace of lemon. Such a sweet young kid. Thirty, at the oldest. Ten years her junior. Yet something about him attracted her.

"Um, yes. The war has resulted in a few changes, I'm afraid."

"Wouldn't you be more comfortable sitting?" He gestured to the sofa.

"I suppose so."

He sat beside her, so close she could feel his warmth. Was he trying to seduce her? Homely single woman, devoted to her career because her career was all she had. Did he think . . . ?

"It's so senseless," he said. "The war, I mean. All Ceres wanted was its independence. Where's the harm in that?"

"Then your loyalty is to . . ."

Jalen shrugged. "I've lived here for nine years. It hasn't been an easy life, I

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admit. People still see me as an outsider. Especially now, they can be pretty mean."

"Have you family on Earth?"

He glanced at the hologram. "My mother. I originally came here to earn some extra money so my parents could save the farm. The depression was hard on farmers, you know. For the first seven years, I wired most of my earnings back home. When the war broke out, I didn't have enough to book return passage. Since then, I've just been trying to fit in here. This is my home now."

She stared at him, aghast. "You're a fool," she blurted. "Why would you do that? Why would you send all your money, your hard-earned money, to someone else?"

"As I said, she's my mother."

She fidgeted, uncomfortable. "I see. Well, you are in a bit of a jam, aren't you?"

His bright smile contained such innocence. "I suppose it would seem that way to someone who's never met her own parents. Were you raised by a foster family?"

"No," she said, feeling suddenly warm. "I grew up in institutions. You see, I wasn't exactly an . . . attractive child. The adoption process can be quite cruel."

"I find that hard to believe."

"Please, Jalen. Mr. Croft. I'm here to talk about you. I'm not sure you appreciate the seriousness of your situation."

"Then enlighten me."

She felt sad. Such a good man. It wasn't fair. "You've heard the rumors, no doubt. The requirements for citizenship."

"Yes."

"It's mostly easy. A test on the history of Ceres Prime. An oath of allegiance. And then, of course, the final act."

"The execution of a war criminal."

"Um . . . yes."

"It's true? I always thought that was a myth. I mean, they can't expect me to kill someone."

"A criminal, Mr. Croft. Someone who tried to destroy us."

He looked down, the smile leaving his face for the first time. "I know. And I guess I understand the principle behind it. It's just . . ."

"Failure to comply means deportation," she reminded him. "The gravity of Earth, after nine years here . . ."

He was still looking at the floor.

"Mr. Croft, we must be clear on this. There is no option. There are no exemptions. If you don't comply, you will be deported. You'll die."

He looked up at last. She could not believe that anyone's eyes could be so blue. "Then," said Jalen Croft, "we have a problem."

Miharu Yamanaka stayed up half the night, plugged into the CeresNet, searching for some alternative. In the early days, the choices hadn't been so limited. With a dozen colonies spread through the asteroid belt, if one denied citizenship there was always another. But since the war, the colonies had banded together, adopting the same laws, the same hatred of Earth. Even Pallas would no longer accept immigrants rejected by another colony.

Loopholes? The law didn't apply to those sixteen and under or those sixty-five and over. No help there. Even the exemption for the handicapped had been repealed.

There has to be something, Miharu thought, desperation rising in her throat. Something about Jalen Croft had gotten to her, in a way that had never happened before. There had been failures. Only six months earlier, she'd been forced to send a family of four to the deportation ship, where their fate had been sealed the moment the hatch was shut. There had been suicides, and there had been those who ran, who tried to escape the inevitable. Ugly, these incidents, and she had empathized to some degree. But the law was the law. What could she do?

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Jalen's blue eyes seemed to watch her from the window of her memory. Am I being a silly old girl? she wondered. Or is he trying to use me? No. His innocent charm was genuine. She'd never been more certain of anything in her life.

The court system would no longer hear cases from deportees seeking to remain. If the final requirement wasn't met, there was no place on Ceres, or anywhere in the Belt, where they could find a safe haven.

Miharu leaned back from the terminal, rubbing her eyes, trying to think. The choice was a simple one, the alternatives nonexistent. If he wanted to live, he would have to kill. There was no other way.

She closed her eyes, and half asleep, a dream image formed in her mind. Jalen Croft, standing at the barrier, a weapon in his hand. Only she was the prisoner bound on the other side.

His finger curled around the trigger . . .

"Ms. Yamanaka. Miharu. It's good to see you again."

Miharu had knocked, out of some sense of respect for Earth customs. Now she stood at the door, waiting for him to invite her in.

"You look very pretty today," Jalen said.

Miharu blushed. She'd put on makeup and done her hair, for the first time in recent memory, and despite the fear that she was being too obvious, his compliment warmed her.

"Thank you," she said. "I've . . . come to discuss your . . . situation."

Jalen smiled. Miharu felt like giggling. This is totally inappropriate, she told herself. I'm his caseworker. And I'm bearing the worst of news. Her feelings wouldn't obey. She felt like bubbles inside.

"Please," Jalen said. "Come in."

The apartment was unchanged from her first visit, but now she saw it with new eyes. Jalen was here, in the vial of Earthdust, in the photos that adorned every wall. Most people covered the interior surfaces with holograms, views of trees or a beach so lifelike you couldn't distinguish them from reality. She'd wondered, on her first visit, why Jalen did not; now she knew. He had wired the bulk of his money to his parents on Earth, every month for seven years. Photographs were all he could afford.

"Tea?" he asked. "Or perhaps a glass of wine?"

She sat on the sofa. "I'm tempted," she confessed, "but I'm here on business. Tea will be fine."

He crossed to the kitchenette in one sailing leap, returned momentarily with two wine glasses filled to the brim with iced tea. Smiling at the gesture, she took the glass he offered her.

This is all wrong, some part of her mind kept saying. You have to keep this professional.

"So tell me," he said, still smiling, "any luck?"

She took a sip of the tea. It was sweet, with just a trace of mint. "I'm afraid not. I stayed up all night searching the net. There's no precedent we could use to get an exemption. There are no loopholes anywhere."

His smile faded briefly. When it returned, it seemed forced.

"I'm sorry," she said.

He shrugged. "You've done a lot to try to help me, Miharu. More than I could possibly have expected. I guess some things are just meant to be."

"You can't believe that. This means your life."

"Can I ask you something?"

"Certainly."

"Am I an evil man, do you think? Do I deserve to die?"

She stared at him, unbelieving. "Don't even say such a thing! You are the kindest, gentlest man I have ever met."

Now it was his turn to blush.

"I'm sorry," she blurted. "I just meant that—"

"It's all right," he said, taking her hand. "I'm just confused by all that I'm

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feeling."

You aren't the only one, Miharu thought. "Have you contacted your parents?"

He looked down. "My father passed away last year. My mother didn't take my news very well."

"Will she keep the farm?"

"I'm not sure. They only allow a single three-minute call, and we were cut off before I could ask."

"That must be terrible, never being able to know." It was the wrong thing to say; she knew it at once, by the quick tears that came to his eyes. "I'm sorry, Jalen. I am so sorry it has to be this way."

He was still holding her hand. Now his grip tightened as he pulled her toward him. Before she knew what was happening, their lips had touched. An electric tingle seemed to pass into her body.

"No," she said, pulling back. "I can't."

"Why?"

"I . . . It's not right. I feel like I'm taking advantage."

His smile returned, softer than before. "I'm on the suppressors, if that's what you're worried about. All resident aliens are. Nothing can happen."

She shook her head. A thousand voices seemed to be talking at the same time. What was she to this young man? Mother? Lover? Would-be savior?

He's leaving to die!

"Miharu, what's wrong?"

She put her hand to her face, pinched the bridge of her nose. "This can't be happening. I've been so alone, Jalen. You couldn't possibly know."

"Don't be too sure about that."

"And now I've met someone who doesn't make me feel ugly or old, who makes me feel like a woman. And in less than a week, if you don't . . . they'll—"

"Shhh. Don't say it."

"Will not speaking of it make it go away?"

He shook his head. "Why were you abandoned, Miharu?"

"Pardon?"

"It was the birth law, wasn't it? Your parents exceeded the limit."

She nodded, flushed. "Controlled growth! If Ceres is so concerned with population control, why let so many immigrants—I'm sorry. No offense intended."

"None taken. But do you see my point? Your parents did what they had to do when they gave you up. They had no alternative. Neither do I."

"If only I could find a way," she moaned. "I tried. I really tried."

"Some of the guys at work were talking. I overheard them; they don't really make small talk with me. Something about a drug therapy. Steroids, I think. To make you strong enough for the g-force."

Miharu only heard that he was going, that he had no intention of changing his mind. "I'll check into it," she said, rising from the sofa. "But don't get your hopes up."

That night, Miharu felt strangely lethargic. She went to bed early, but despite her growing sleep deficit she lay there for over an hour, her eyes wide open and her thoughts scurrying around each other like a pack of predators engaged in mock combat. Finally she did sleep. Or she must have, because she had the same dream as before. Only this time Jalen was the prisoner, bound and blindfolded, and it was she who pulled the trigger.

The next morning, Hemani Losura stopped by her cubicle to ask why she hadn't moved on to her next assignment. She explained the difficulties she was having, and while he seemed sympathetic, he urged her not to waste more time on one man.

"There are others who need your guidance," he said. "If Mr. Croft has made his decision, there's nothing more you can do."

She mentioned the drug therapy.

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"Yes," Losura said hesitantly. "There has been some success with steroids and exercise, even on long-term residents. But the cost is frightfully high. Has Mr. Croft the financial resources?"

"I'm not sure," she lied. "But I'll check into it."

"Miharu, are you becoming personally involved with this man?"

She felt the beginnings of a blush, tried to suppress the response. "I'm trying to save a life," she said simply.

Losura nodded, eyes bright in his ancient face. "Commendable, if that's all it is. Very well. I'll give you one more day on this. After that, whatever the outcome, I'll expect you to move on to the next applicant."

He left her cubicle, and Miharu breathed a sigh of relief. Then she checked her savings account balance against the cost of the treatment. She could afford it, even if Jalen could not.

"Ms. Yamanaka, isn't it?"

Miharu bowed. "I'm sorry for the short notice. Do you have the records I requested?"

The clerk fidgeted. "Geneprint access is on file for all resident aliens, yes. But I need authorization before I can release them to you."

She smiled, trying to appear casual despite the pounding of her heart. "Hemani Losura has granted me access," she said. "You can contact him at the Office of Immigration and Naturalization, if necessary." She held her breath, hoping he wouldn't check. Losura would probably authorize it, but there would be questions.

"That won't be necessary," the clerk finally said. "The reader's over there. Make yourself comfortable. I'll be back in a second."

And he was, and he had the file on Jalen Croft. He watched as she ran the print through the reader and cross-referenced. A moment later he touched her wrist, asking her why she was crying.

* * *

Miharu watched from the observation room as the workers toiled at the mine. Ceres Prime was constantly expanding, as the asteroid's core was hollowed out, new chambers cut from the rock, the debris carted away to be processed into building materials. One day in the distant future, it would be a hollow ball, its interior wall the floor of a world spun to produce centrifugal force. When that day came, Miharu mused, a trip to Earth would no longer mean death.

She spotted Jalen as he was coming off his shift, blue coveralls covered with dust. He didn't see her, so she watched him for several minutes. The other workers were talking and laughing, but Jalen walked alone, an invisible shield surrounding him. When he bumped another worker by accident, the man spun on him, shouting and gesturing angrily. She couldn't hear anything from behind the window, but she could imagine Jalen's apology, his passive disarming of the aggressor.

She waited for him at the exit, wondering how he endured it all. How did he remain so kind to those who shunned him? Why didn't he become bitter, begin to hate them? She felt ashamed of those men, ashamed of herself for being a part of such an intolerant society. For the first time in her life, she found herself questioning things she had always taken for granted. Was Earth right? Were they being selfish, claiming this minor planet for themselves and using force to defend it? They all had roots on Earth. No one on Ceres, or anywhere in the Belt, was more than one generation removed from the Mother World.

"Miharu? This is a nice surprise."

She looked up, and there he was. She opened her mouth to speak, but suddenly her heart was pounding and a fist seemed to be squeezing her throat.

He hugged her. "I was thinking about you all day. I couldn't stop. Isn't that weird?"

He was like a child, she thought, a little boy. His appeal was pure and simple,

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irresistible. "Not so weird, I think."

He looked at her, perhaps sensing the news she had to tell him, but then he smiled, and he kissed her.

"Get a room, you two."

Miharu looked up at the workers filing past into the main tunnel. Those who looked their way wore frowns of disapproval or laughed, pointing. Knives in her heart.

"Let's get away from here," she suggested. "Are you hungry?"

Jalen smiled, taking her hand, unmindful of the stares of his coworkers. "After a twelve-hour shift? I think I passed hungry four hours ago."

They took the tunnel to the main hub, where restaurants and shops lined the way and the crowd contained faces she didn't recognize. There was anonymity here, with the general population unaware of Jalen's status. By the time they'd chosen a delicatessen and settled into a table with their sandwiches—his roast beef, hers cucumber—she had almost forgotten the intolerance she had glimpsed at the mine.

"We found another mineral deposit today," he said around a mouthful of sandwich. "Iron, mostly, but with traces of uranium mixed in. Everyone's excited. Bonuses, you know."

Miharu swallowed, smiled encouragingly. "That's good news. Your coworkers could have been more upbeat."

Jalen shrugged. "They're all getting together for a party in C-Ring. But I'm not much of a merrymaker."

"You weren't invited?"

He looked down. "No."

"Why do you let them treat you this way? You're just as much a human being as any of them. More so."

He looked away, uncomfortable. "It's . . . their way. They've all lost someone in the war—a father, a brother. They need someone to blame."

"But you're one of us. You haven't killed anyone, couldn't kill anyone."

"That seems to be the problem."

Now it was her turn to avert her gaze, ashamed. They finished their meal in silence, then walked the ring, window-shopping. For a time it all seemed so natural, so right, that Miharu forgot the terrible news she had come to tell him. Then they were at his apartment, and he was looking down at her with those huge blue eyes, and she knew she couldn't go on this way, knowing the truth while she kept him in darkness.

"I checked into the steroid treatment. It's expensive—very expensive—but I thought if I helped you could do it and get an extension so by the deadline you would be strong enough and you could return to Earth, your mother's waiting for you, and I would miss you but at least you would be happy and then maybe someday when the war—"

"Miharu."

She took a breath. "Sorry. So much inside is trying to get out."

He held her face in his hands. "I know. But you were making me dizzy."

She smiled, wondered at his blurriness. "You can't have the treatment," she said. "It's your DNA. Fifth chromosome, to be exact. If you took the drug, you would experience liver failure and die."

He nodded, showing no emotion. "I figured there would be a catch. It was too easy, too good to be true."

"I tried, Jalen. I would have given my life savings to make it work for you."

He stroked her cheek, his fingers so big, so warm. "I know. But that's it, isn't it? If I stay, I'm a criminal. If I go, I die." The way he said it, with such resignation, made her breath catch in her throat. "Thank you for being honest with me, Miharu. And thank you for trying. Most of all, thank you for caring. No one else ever has."

He went all blurry again, and she felt warm wetness on her cheeks. In the feeble gravity, the tears just hung there, collecting into pools until he wiped them away and leaned down to kiss her. At first his lips were gentle, soft. Oh, how she'd fantasized about this moment!

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Ever since their last meeting, she'd thought of nothing else but the way he made her feel, when his lips touched her own, the way he awakened something that had been sleeping inside her.

She kissed him back, hunger pushing aside tenderness as his arms encircled her and she clung to him, heart pounding, breath coming in gasps, knees trembling. Before she knew it, they were on his bed, his mouth at her neck, her earlobe. And though her desire had never been so strong, her mind would not surrender. Not yet.

"Jalen, no. I'm practically old enough to be your mother. And look at me. Why would you want to be with someone who's so . . . ugly?"

He drew back enough to look her in the eyes. "You should see yourself," he murmured. "Your beauty is something you've kept imprisoned inside you, all these years. Only now it's been released. You are more radiant than the Sun."

She smiled, laughed, and when he kissed her again she didn't pull away. Nor did she stop him as his mouth moved lower, as his hands unbuttoned her blouse, everything, until she lay naked in his arms, feeling not embarrassed or ashamed, feeling alive.

"But the suppressors . . ." she protested.

His tongue brought fire to her nipples. He laughed softly as he traced a line down her abdomen, then lower. She let out a gasp of surprise, and then, for a time, it all went away—Ceres, Earth, the citizenship oath. Nothing mattered but this beautiful man and the things he did to make her feel, at last, like a woman.

After the third time she lay contented in his arms, her cheek resting against his chest, soothed by the gentle rhythm of his breathing. She drifted to sleep with a smile on her face, forgetting quite completely how it all must end.

The next day at work, Miharu felt as if she was moving through a dream. People glanced at her in ways they never had before. When someone commented how pretty she looked, she fell speechless.

Slowly, reality began to return. The deadline was approaching, as inevitable as the orbit of Ceres around the Sun. Part of her wanted to pretend it wasn't there, that this new happiness would never end. But she'd always been a realist, and by midday, when the lists of those scheduled for deportation had been compiled, she knew she had to act.

"Miss Yamanaka. What can I do for you today?"

Hemani Losura sat behind his desk, his wrinkled face tight with concentration. As Miharu sat opposite him, she felt she was seeing her super- visor for the first time. Beneath that stern expression, wasn't there com- passion? Behind those hard eyes, wasn't there understanding?

"Sir, I . . . am concerned. It occurs to me that our system may be too harsh. Who are we, after all, to hand out sentences of life or death?"

Losura steepled his fingers and regarded her with a steady gaze. "The system is what it is, Miharu. We do not create it, but merely act within its constraints. What would you have of me?"

She frowned. "I think we do create it, every day, with every person we condemn to die. It isn't right that we force prospective citizens to kill in order to join our society. Is that the kind of citizens we want? Murderers?"

Losura never blinked. "You've become too involved with this . . . What is his name?"

"Jalen Croft, sir."

"Then. Your personal life is no concern of mine, but I'm inclined to remove you from the case. There are plenty of other—"

"No! Sir, I implore you. I must—"

"You can do nothing. I've been monitoring your activities. You have gone beyond your duties for this man. I would

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ask you to tell me why, but that would only be stating the obvious. Really, Miharu, do you realize what pain you bring on yourself?"

"Sir, I came here to ask a simple question. Can't we make an exception? He is a good man. He will not take a life, not even to save his own. Can't we show some compassion for such an innocent?"

"Innocent? Seventy thousand people died when the Earthers melted Psyche. Who is innocent? The pilots of those warships? The designers of the missiles? The inventors of their propulsion systems? The farmers who fed the workers who constructed them?"

"Sir—"

"No. This meeting is concluded. You will resume your duties at once."

"Then you're removing me from the case?"

A gleam in his eye revealed a depth she had never glimpsed before. What lay within remained a mystery. "Quite the contrary," he said. "I am leaving you to it, to the very end. Maybe then you will learn the value of detachment."

They spent their last day together at the hologram gallery, where images of Earth burned with such intensity that Miharu found her eyes watering and her soul longing to lose itself in this place of dreams.

The sky: a blue that stretched to infinity, that whispered of peace, serenity, that pulled her in every direction until she felt like a bubble about to burst. Against that vastness, she felt very small, very contained in the feeble shell that was her flesh.

The sea: passion flowed here, in waves against a glistening shore. Life pulsed to the rhythm of the tides, and death was the unseen undercurrent that drove this vast engine of renewal. Clouds cast [illegible] shadows upon the water, moving patches of darkness where the water became more green than blue and where you could see down into the depths just enough to know that another world waited below.

A jungle with a thousand shades of green, a thousand lives hurrying along their courses, a thousand lessons of love and justice, of balance and the will of the strong to survive. Stars at night, turning slowly around the sky, distant echoes of those who once watched, of civilizations that rose and fell while still those same stars looked down, unchanging and eternal. Rivers. Glaciers calving off into the sea. Wind blowing sand across the desert. On Ceres, the eye never touched on anything more than a few meters away. Here, in this magical place, you could look and look forever, never seeing the end.

"It's beautiful," Jalen sighed. "More beautiful than I remember."

Miharu held his hand, fed on his warmth. They were alone here: the hologram gallery, once popular, had fallen into disuse with the current political climate casting Earth as the villain. Perhaps it would be torn down in time, she mused, the space used to store weapons intended for that very world's destruction.

"I wish I could see it," Miharu said. "I wish we could see it together."

A ragged sigh escaped him, and she looked up to see that he was crying. Before them, a mountain rose out of the clouds, its peak dazzling orange in the setting sun. Jalen seemed not to see it at all.

"You're sad," she said.

He blinked, causing a single tear to drop in slow motion from his eye. "I guess it never hit me until now. This is my home. Tomorrow I board a ship bound for this place, and when I get there I'll see all this one final time. Then this blue sky will kill me."

She shuddered. His optimism had been a shield, she suddenly realized. Now at last the shield had been lowered, and she saw the fear behind it.

"I did a foolish thing," she said, clutching his arm to her. "I shouldn't have

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brought you here."

He shook his head, seeming very far away. "No. You did a wonderful thing. This is the best gift you could have given me."

She felt hollow, empty inside. "I did another foolish thing," she said. "I fell in love with a man I was destined to lose forever."

He put his arm around her, looked away from the dazzling peak, his eyes aglow in the orange light. In silence they walked the tunnels of the city, until at last they returned to the place where they'd first met. She sat on the sofa while he brought wine from the kitchenette and sat beside her, dark thoughts behind darker eyes.

"I can't believe I've finally found someone to make me feel this way," he said, his voice toneless. "And now I'm going to lose her. It seems such a waste."

She took a sip of wine. Its sweetness was lost at once in the bitterness within her. "No," she said. "It cannot be. I won't let you go."

"You've no choice."

"Then I'll come with you."

"But you'll die, too."

"I don't care."

He turned on her then, anger in his face. "Forget such foolish talk. You did everything you could for me. I won't let you die for me as well."

"And the rest of it?"

"It was a mistake. It should never have happened."

"No! You know that's not true."

For an instant, a softness returned to his eyes. Then it was gone. "Get out," he said, rising from the sofa and crossing to the door.

"Jalen?"

"It's bad enough for me to die. I won't let you destroy yourself for no reason."

"I love you. Isn't that reason enough? At least we'd be together for the voyage."

"And when we arrived at our destination?"

"I'm not afraid."

"Then you truly are a foolish woman. You've lived alone for so long you would throw your life away for a few moments of companionship. You disgust me."

Her face grew hot as she sprang from the sofa, tossing her wine glass aside and rushing toward him, her fists raised in front of her. He didn't even defend himself as she rained blow after blow down on his chest, and when she drew back at last, her energy spent, his expression hadn't altered.

"Good-bye, Miss Yamanaka. Thanks for your assistance in this matter."

She stood outside the door, looking in. There, on the table, the vial of Earthdust. There on the wall, the hologram of his parents. She felt in that moment that she had never really known him, that she had only thought she had.

"This can't be how it ends," she moaned. "This can't be how we say good-bye."

He looked down on her like he would an insect, and his smirk made her feel ugly, unworthy, contemptible.

"It is," was all he said, and then he slammed the door in her face.

From the observation deck, Miharu Yamanaka watched as the citizen rejects were marched up the ramp and into the dark interior of the deportation vessel. There were so many of them. Why were there so many?

He didn't even come to say good-bye.

The thought circled in her head like one of the predator birds from the hologram gallery. He hadn't really cared about her, after all. She had fooled herself, allowed him to use her, and when it became clear that she couldn't help, his affection had evaporated like fog under the morning sun.

No.

She couldn't, wouldn't accept that. After a lifetime of waiting, she had finally found someone to love, to make her feel like a woman. That was how she would remember it. And in her memory,

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he would be here, holding her hand, looking deeply into her eyes, not vanishing faceless into that ship of death.

The ramp was retracted, the moorings released. Miharu watched as the vessel crept through the open hangar doors. How many hundred were they, these men and women sent home to die? Some would live, at least, those on the steroid treatment, those not so long from the gravity well of Earth that their bodies would forget. But most of them would perish, their bones breaking and their organs bursting under the unaccustomed weight.

Jalen would be one of them.

Miharu felt cold, empty. What could she do now? She was a part of the system that enabled this atrocity. How could she go on, day after day, knowing what role she truly played? The urge was fleeting but intense: to throw herself through the window, into the vacuum beyond. Her life was over. Why not join the one she loved in death?

Instead she pressed her hand against the cold glass. "Good-bye, Jalen Croft. Thank you—for everything."

A shudder passed through her body, and she turned.

"Jalen?"

He stood there, his travel bag over one shoulder, that little-boy smile on his face. "You were right. That was no way to say good-bye."

She rushed into his arms, kissing his face, clutching and trembling, weeping, laughing.

"What have you done?"

She looked up into his face, and in his eyes she saw the dark glint of terrible choice. "I've decided to take the oath. For you. For us. It's not too late, is it?"

She frowned. "The deadline has passed, but I can pull a few strings. Are you sure about this?"

He nodded. "What choice do I have?"

"But . . . you said . . ."

"Forgive me. I was a fool. I thought it would be easier for you if you hated me."

She sighed, some tension within her released at last. She wanted to melt into his arms, as she had longed to join that hologram sky, but there was no time for that.

"Come," she said, taking his hand. "We must hurry."

The assembly hall was packed with the next group applying for citizenship. Miharu filed the necessary papers for a retroactive extension, and as she sat in the gallery listening to the administrator's speech, she watched Jalen, so far below her, and her mind fell into turmoil.

"Since the first pioneers set foot on this world, we have sought to build a better society, a place free of hate and fear. Thus was Ceres born, seventy-five years ago. A great voyage, the hardships of an untamed frontier—these were as nothing compared to the trials that were to follow, as Earth rejected our claim of independence and sought by force to keep us bound to the Mother World forever."

He had to do this, she kept telling herself. If he refused, he would be deported on the next ship. But if he went through with it, would she still love him as a killer?

"Each of you was born on Earth. That in itself is no crime." On and on it went, until finally: "As your name is called, please step forward and take your place at the barrier."

Miharu watched as the prisoners, bound and blindfolded, were put in position and the weapons were checked. Only then did the administrator begin to call names. "Frank Arlington. Celeste Azula. José Buenaflores. Jalen Croft."

Miharu held her breath as he rose from his seat and moved toward the weapon the administrator had designated. There was no hesitation in his stride, and he never once looked back to try and find her.

"Remember," said the administrator, "these prisoners are murderers. Each of

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them was captured in battle, in the attempt to destroy us."

Only a handful of the immigrants had refused to stand. Miharu looked at them—a man in a business suit, a woman with a purple scarf around her neck—and she wondered what emotions they were feeling. Were they, as Jalen had been, torn between life and honor, unable to take this final step? Or did they simply lack motivation, a strong enough reason to do what must be done?

"Prospective citizens, take your weapons!"

Miharu watched, feeling like it was a dream, as Jalen put his hands to the gun, curled one finger around the trigger.

"Aim!"

She closed her eyes.

"Fire!"

The sharp explosions of weapons firing made her jump—once, twice, three times. Then together, too many to count, and she was spinning, falling, wishing it would all go away, afraid to open her eyes for fear of what she would see.

"It is done," the administrator said at last. "Those of you who failed to fire your weapons, please report to the Blue Room for immediate deportation."

Miharu opened her eyes. Jalen still sat clutching his weapon, his arms and neck rigid, tears flowing from his eyes. The prisoner before him, a young black man, was still alive.

"Miharu Yamanaka, please report to the Blue Room."

Miharu blinked, looked up to see that the assembly hall had emptied. The Blue Room? Never before had she been called there. As she rose to her feet and made her way through the rear exit, she wondered what more they could do to torture her. Why not, as in the dream, just have her kill Jalen herself? Surely that could be no more painful than the false hope she had endured, only to fail at every turn and then, in the end, surrender to the inevitable.

The Blue Room was guarded by one of the administrators, but he stepped aside at once, allowing her to enter. Inside, to no great surprise, stood Jalen, as well as the others: the man in the business suit, the woman with the purple scarf. And one other.

"Ah, Miharu. Thank you for joining us." Hemani Losura greeted her with a smile, shaking her hand before moving to the front of the room and signaling for the others to be seated. That smile never left his lips, even as he ordered the remaining administrator out, to lock the door and remain in the hallway. Could he be so cruel?

"What I'm about to tell you is never to leave this room," Losura said. He shuffled through some papers, and it was only when he raised them that Miharu realized what they were. Her breath left her in an involuntary gasp.

"Congratulations, new citizens of Ceres Prime. Please accept these certificates with my deepest hope that you will find happiness and prosperity among us."

Confused mutterings filled the room. Miharu moved to Jalen's side as Losura handed him his certificate.

"But . . . sir? I don't understand."

Losura looked down on her, kindness in his eyes. "A necessary deception, my dear. Those who will kill in cold blood have no place among us, even if it is only hologram prisoners they shoot. We seek to build a new society, after all, a world free of the hatred of Earth. So it is those who fail the final test, who are unwilling to commit murder even to save their own lives, who are granted citizenship."

"But that's . . . that's . . ."

"I know. It was a shock to me when I learned the truth. I hope you see why it must be so."

"I do not."

Jalen was looking at his certificate, holding it as if the parchment were made of gold.

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"Public morale," Losura said. "Bitterness toward Earth remains, and until the war is over there's no avoiding it. This way new citizens are accepted as comrades."

"But it's all based on a lie!"

Losura nodded. "A necessary lie. Maybe someday we'll let the truth be known, but for now I must ask you to maintain the lie, as all new citizens do."

She shook her head. "How do you manage it? Surely they have friends, coworkers. People talk. The truth has a way of rising to the surface."

Losura smiled. "You were a good choice, Miharu. Yes, it's a challenge. But with the ceremony closed to the public, only the other immigrants in attendance could identify the new citizens as people who were supposedly deported—"

"And since they aren't around to make such an identification . . ."

"Precisely. It's not absolutely airtight, but it works. For now. In time, we hope, all of this will become unnecessary. It's up to people to change."

Miharu frowned. "Why tell me? Why let me in on the secret?"

"All agents of the Office of Immigration and Naturalization are kept in careful ignorance. Compartmentalization is strictly enforced to ensure that no one sees the complete picture. Otherwise, the deception would not ring true, and prospective citizens could not be accurately screened. But you, my dear—I've chosen a special path for you."

She just looked at him.

"I'm close to retirement. I've searched a long time for a worthy successor—someone with a true heart, who genuinely cares about Ceres and her citizens. Someone who would do what must be done, who would never choose the easy path simply because it was easier."

"You can't mean . . ."

"I do. This assignment was carefully chosen, your final test. Miharu Yamanaka, it would honor me greatly if you would accept a promotion to director, effective immediately."

"I . . . don't know what to say."

Jalen elbowed her. "Yes, you do, my love. You say 'yes.'"

They lay in each other's arms, the new apartment feeling at last like home.

"So that's what you're like without the suppressors," Miharu said.

Jalen sighed. "So now we live happily ever after?"

She kissed his shoulder. "Very happily."

He smiled. He made love to her again, and again, and it was late into the night before they lay still again, looking up at the blue hologram ceiling.

"You're troubled," he said.

She frowned. "Now I am the Keeper of the Secret. It's a great responsibility. I'm not sure I believe in the system. How can I be depended upon to uphold it?"

He held her gently, his warmth a nourishing aura that engulfed her. "Things can change, in time. Now you're in a position to do something about it."

"And now I have a reason."

He was silent.

"Jalen?"

"I was just thinking. There's another oath I'd like to take, when you're ready."

Her breath caught in her throat. "Would you really want to marry such an ugly duckling?"

He laughed as the hologram sun set and the stars burst forth in all their glory. "You are such a fool, little Miharu Yamanaka. You are the most beautiful creature who ever lived, and you don't even see it."

She rested her chin on his chest. "Then the answer, Mr. Croft, is yes. Now and forever—yes."

He kissed her forehead. "I would have asked you sooner, but I was afraid you'd think I was only marrying you to gain my citizenship."

She hissed, and then she kicked him.■

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Crow's Feat

John G. Hemry

Any researcher welcomes the chance to confirm a hypothesis. But confirmation isn't always what you'd expect . . .

An odd quiet pervaded the crowded city, a quiet filled with the cries of humanity and assorted animals, punctuated by the creak of wood in wheels, doors, and beams. Paul Randal Gallatin, unnerved by the absence of machinery clamor and amplified music, shivered occasionally as he inhaled a pervasive, ever-changing and incredibly foul mix of stenches which filled the air in counterpoint to the lack of noise. He hesitated, warned by some sixth sense, just before a cascade of filth plummeted to the cobblestones immediately ahead as some upper-story occupant emptied a chamber-pot into the street. The romance of Elizabethan England, like forbidden love, it seemed, was best admired from afar. Up ahead, Gallatin finally caught sight of his goal, the tavern where hopefully discreet inquires had led him to hope he would find his quarry.

Cocktail Party. Paul Gallatin switched hands on his beer, hurriedly wiping the now-free right to rid it of moist condensation before shaking the hand proffered by a slim man whose haircut was exceeded in cost only by his designer suit. "Heyniceseeingyou. Whatdoyoudo?"

Gallatin nodded politely. "I'm a writer."

Eyebrows rose dramatically. "Really? That's great. What do you write?"

"Novels and short stories. My latest book is part of the Servian Quadrant series."

"Can't say I've heard of that. Sounds like astronomy or something."

"Science fiction, actually."

The eyebrows dropped. "Oh. So you aren't a *real* writer."

Gallatin bit back his first reply, then smiled thinly. "How about you? What is it you do?"

"I'm a lawyer," the expensive suit noted with obviously forced modesty.

"A lawyer?" Gallatin let his eyebrows rise to match the earlier gesture aimed at

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him. "So you fight battles in the courtrooms? Confront murderers and get them to confess their crimes?"

"No, not that. My specialty is patent law."

"Oh. So you're not a *real* lawyer." Gallatin left the suit standing, mouth agape, to make his way to the buffet table. He hadn't quite reached it when another hand thrust into his field of vision.

"Greetings! You're Paul Randal Gallatin? You're a good writer."

Gallatin smiled back at a chunky man grinning heartily through a dark beard. "I like to think so."

The other man nodded. "As you should. What we think of things matters a great deal. That's quantum physics, you know." He leaned forward conspiratorially. "And I'm a physicist. Name's Ivan Grashchev, but call me Ivan Ivanovich."

"Ivan...? I've heard of you."

"Thank you," Ivan beamed. "I like your books."

Paul Gallatin smiled again. "No. Thank *you*. I didn't expect to meet a fan here."

"Then why did you come?"

"Hopefully to generate some new fans. I need every one I can get."

"Better stay away from the lawyers, then." Ivan strolled toward the buffet, urging Gallatin along with one hand. "I'm surprised, though. Your books sell pretty well, don't they?"

"Pretty well isn't good enough today." Gallatin took a deep breath. "The publishers want bestsellers, and nothing but. I'm what they call a midlist writer. I sell enough to generate some profit, but not enough by their standards."

"You don't sound too happy."

"I'm not." Gallatin stood beside the buffet, waiting while Ivan shoveled a wad of thin-sliced ham into his mouth. "It gets old. I've thought about quitting. You pour your heart and soul into writing, and connect with some people, but it's like the Red Queen's race."

Ivan nodded in understanding. "You have to run as fast as you can to stay where you are? I guess every writer can't be Shakespeare."

Gallatin grimaced. "Shakespeare? Don't get me started. That man never wrote a word."

"Ah. Are you an Oxfordian, or something more exotic?"

"I've never decided. But how can you hand some man the mantle of the greatest writer of all time when we have absolutely no manuscripts in his own hand, and he left a will which didn't even mention his alleged writing?"

Ivan grinned. "Would you like to write a bestseller, my friend? Be a 'real' writer and make your publishers beg for more?"

"Sure. Have you invented a magic lamp I can wish for that on?"

"Maybe." Ivan grinned wider. "My lab's in this building, you know. Used to be in the basement, but when scientists win enough awards they move them into nice, clean labs where they can see sunlight and be shown off. Want to come see what I've done?"

"Sure. At the very least it might inspire a story." Gallatin followed as Ivanovich headed out of the room, veering off course slightly to refresh his drink at the bar. An elevator dropped them several stories, then paused expectantly until the scientist slid a card into a waiting slot to trigger the doors open.

The lab looked suitably high-tech, marred only by the mess and tangle of actual science underway. Ivanovich led the way over heavy power cords until they reached a large gleaming box in one corner, its dimensions broken on one side by a small shelf holding a laptop hard-wired in place. "Lovely, isn't it?" the physicist beamed.

"Uh, yes. What exactly is it?"

"A mass-particle reorientation device. You realize time is just a measurement we apply to particles, correct? So, it's quite simple, actually," the scientist ex-

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plained, gesturing with his drink while his other hand stroked the stainless steel exterior. "You know how every advance in quantum mechanics has occurred?" Without waiting for a reply, Ivanovich continued speaking, even as he began punching commands into the keyboard. "You simply have to believe everything you knew beforehand is wrong. So, lo and behold, I applied that philosophy to the problem of what you would call time travel."

"Time travel?" Gallatin stared at the mechanism. "You're joking."

"Not at all. And this little toy, my literary friend, is going to make you and me rich and famous."

"Rich and famous?" Paul Gallatin laughed. "What are you thinking, we should go back and bet on horse races we already know the results of?"

Ivanovich waved his drink again, this time dismissively. "No. That sort of thing is for people with no imagination. But you and I, we have imagination, right? Tell me, how many copies do you think a book would sell if it proved your belief that Shakespeare was a fraud?"

"There's been a lot of theories—"

"No theories!" Ivanovich wagged a reproving finger. "Proof. Evidence. Incontrovertible."

"Ivan, if any such evidence ever existed it vanished a long time ago. You'd have to go back to Elizabethan England..." Gallatin's voice trailed off as Ivanovich smiled hugely. "My God. You could do it. Find handwriting samples, talk to people who knew, place the real evidence where you could be sure it would survive and where only you knew to look. Even talk to the man himself!"

"Exactly." Ivanovich typed a few more figures. "It's all ready. Have a nice trip."

"What? Me?"

"Of course, you." Ivanovich swallowed the rest of his drink. "I don't know the right things. I build machines. You know literature and history and enough about this Shakespeare to find the truth, right?"

"Well, yes, I think so. Maybe. It's just that—"

"Here's your chance to live one of your fictions. Then write a book which will be a bestseller, make a few millions, make us famous."

"Isn't it dangerous?" Gallatin wavered.

Ivanovich shrugged. "Crossing the street is dangerous. Hey, at least back then you can't get run over by a car, eh?" He dug in one pocket for a moment, then offered a few coins to the writer. "Elizabethan currency. Not much, but you might need a little."

Gallatin took the coins, his mind still churning. "Do you always carry Elizabethan currency in your pocket?"

"Only when I know a certain writer is coming to a party. Sometimes even us non-writers can predict the future, you see."

The tavern's greatroom, its outlines obscured by weak illumination coming through small, heavily-leaded windows, stank of other smells than those which warred outside. Against one wall a table rested, its sole occupant drinking ale.

Gallatin stared, overcome by emotion despite himself. The man slumped in his seat, eyes fixed on the table before him, looked older than expected, but then he'd already seen enough of Elizabethan life to understand how it would age anyone prematurely. Life, too, presented a million variations in appearance which fixed portraits could never capture, especially those done perhaps a century after a man's death. Gallatin took a few more steps, pausing in front of the man's table. "Are you William Shakespeare?"

Large, soft eyes looked upward, heavy nose seeming to droop over the bushy mustache. "I am. God's Breath, man, hast thou not heard that all my worldly debts have been these last few days discharged? I owe no man in this cluttered dungheap more."

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"I'm not here to collect on a debt. I...merely wished to discuss your work."

Shakespeare's eyes lost their weariness, lighting with sudden enthusiasm. "My sonnets and poems? *Venus and Adonis? Lucrece?*"

"No," Gallatin quickly protested. "Not your poetry. I, uh, admire your plays."

The playwright frowned. "The plays? The comedies, histories, and tragedies? Thou art oddly garbed, and thine accents are outlandish. I did never know my feeblest works were widely hailed. Whence comest thou?"

Gallatin paused, then gestured vaguely. "Oh, from out west."

"West? Thou are not of Devonshire, surely."

"No. Further west. The, uh, New World."

"The New World? Art thou then an Indian such as those the Virginia Company gives report of?"

"You might say that. Yes."

"Fine apparition! I had never thought to meet the like! Yet, thou resemblest not those Indians of my knowledge, and thou sayest thou hast heard of my plays."

"Well . . . ." Gallatin cast about frantically for a story to explain himself, then smiled politely at Shakespeare as clichéd inspiration struck. "I was born to English parents, but our ship was wrecked on the wild coast of the New World, and I was left an orphan, then raised by the Indians there. I heard about your works from the Virginia Company settlers who discovered me."

"A remarkable tale. Come, then, good fellow, and share my table."

"Thank you." Gallatin sat, casting about for a means to direct the subject away from Indians and back to Shakespeare's alleged plays. "I hope to see one of your performances while I'm in London."

His words seemed to amuse the playwright. "Thou hast come fair late for such. On occasion in time past did I prance upon stage, but no more. Two nights hence Stratford-bound I shall be."

"What? Ivanovich's machine didn't get the right year?"

"I know not—"

"I'm sorry. I got here when you're leaving London? Your theatrical career is over? What about your plays?"

"What of them? My rough tales profited me well enough to earn a goodly life in Stratford if well husbanded, but I hold no desire for further labor in similar manner." Shakespeare's mouth worked in mild aggravation. "Best thou should ask of my true art, such as found great favor with the Earl of Southampton."

"You mean your poems?" Gallatin forced a false smile. "They're, uh, very good." Shakespeare brightened again. "But that's too bad about your not writing plays anymore. How does the Earl of Oxford feel about that?" he added with forced nonchalance.

"I assume it matters not to him and his. The old Earl is dead some years gone, and with the younger I have but small acquaintance. Art thou Oxford's agent?"

"He'd like to see your plays," Gallatin suggested casually. "In manuscript. He doesn't have any."

William Shakespeare shrugged. "Manuscript? If thou seekest plays, thou wilt find foul papers in plenty at the Globe Theater amongst the other tools of my theatrical company of old."

"Foul papers? But those are just rough drafts, right? Drafts that many actors have written on? What about a complete, finished play? I haven't been able to find one of those."

Shakespeare shrugged again, his eyes revealing more than a hint of disinterest. "I cannot claim surprise in that. Nor do I know of such Oxford might purchase, nor why he should care."

"Such a manuscript would be valuable," Gallatin protested.

"Of value? Thou again speakest of manuscripts where I labored on plays

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only. Such are not art. They brought profit, but I care little for their fates now."

Gallatin couldn't hide his surprise this time. "You don't care about the rights to your plays? You don't own any of them any longer?"

"Own? The foul papers rest with my theatrical company. I have no claim there. My sonnets and poems hold my art. Hast thou read *Lucrece?*"

"Yes. Of course. A while ago."

"Many have done the same," Shakespeare noted proudly. "Though," he muttered, "much criticism I gained for *Venus and Adonis*. Too popular with the masses, 'tis said. Is this so ill? *Lucrece* proved a graver labor yet found favor as well, so happy result met my perseverance in the face of sneers. But I have tired of the labor, the eternal endeavor to please both critic and reader, and so made shift to sell the drafts of those fine works, my sonnets and poems." Shakespeare drained his tankard of ale before fixing a hard look on Paul Gallatin. "Hast thou never despaired or been in sore need?"

"No. Not at all. I'm a writer myself, in my own land." Gallatin thought desperately, all his preconceptions thrown off balance. "I'm sorry you've decided to stop writing, but I'd be very grateful if I knew where to find a copy of your plays, in your own hand."

Shakespeare laughed suddenly. "Mine own hand? Thou art indeed new to London!" His mirth changed, becoming tinged with embarrassment as he looked away. "Unlettered at birth was I and even now I write but little." One finger tapped his balding head. "Herein lies the baseless fabric of my pageantry. Others scribed the words, midwives even as to Minerva from Jove's brow."

"You didn't write down your own plays, not even the foul papers?"

"Is this so remarkable? I spent my youth at labor, and in similar fashion my adulthood. Such leaves little time for simple labor such as placing word upon page. A man must eat, and work dawn to days-end to earn that meal, unless fortune grants leisure for more."

"But writing was your job!" Gallatin protested suspiciously. "Why couldn't you find time to draft plays?"

Shakespeare flushed, making as if to rise, then collapsed as if deflated. "Rough are thy manners, son of shipwreck, but tell truth and shame the devil, 'tis said. I depart this city and this old accustomed life, wherefore it mattereth not an thou knowest this truth I tell thee, as few others know but good Ben Jonson could confirm of his certain knowledge. I cannot read nor write well, but only with greatest labor, for the words and letters swim before mine eyes in disorder. God Himself hath willed this, it seems, that I should speak fine words but never see them in form I can grasp with comfort."

"There's no surviving copies of your written manuscripts because you couldn't write easily? The signatures are poorly scrawled and misspelled for the same reason? Why didn't I ever think of that?" Gallatin faltered, momentarily at a loss for words. "You're dyslexic."

"I like not this, for I know not this word, and had not known this matter concerned others," the playwright muttered angrily.

"No, I'm sorry," Gallatin offered hastily. "Very sorry. The evidence was there, I just didn't consider all of the possible explanations. I just believed what I wanted to believe."

Shakespeare smiled softly, mollified. "In that thou art but one with all of humankind. True knowledge of past or present is oft of less merit than that history which we desire to be so."

Gallatin looked down before glancing at the playwright again. "I was also jealous, I suppose. Your writing is so...so unparalleled."

"Ha!" Shakespeare laughed with obvious delight. "Too rare is such praise, even from those guided by wishes unknown."

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"You must have heard that kind of praise a million times."

"I say again, stranger to London thou art, and despite your claims unaware of the artist's lot, it seems." Shakespeare made an angry face, rubbing spilled ale into the table surface before him. "My praises come too rarely, and then in main from those groundlings who flock to my plays. Plays! Works of no merit. I care for such fantasies not at all. Yet for my sonnets, art in truth, the self-anointed judges of great art oft time care but little. Not an artist of grave subject am I, they say, looking to *Venus and Adonis*. Upstart crow, said Greene, the fine university man."

"But that last was only one criticism, years ago."

"So thee, who claims status as an artist, forgets the words of those who flay thine art?"

"Ummm, no," Gallatin admitted. "No matter how small or how long ago, I tend to remember criticism more than praise."

"Just so. Yet in mine heart, I oft wonder if I am a true artist, or if here sits a mere dreamer of speculations."

Gallatin froze, his mouth open, then snapped it shut. "Speculations? Critics look down on you, and you question your own merit, because you write speculative fiction?"

"Fiction? If such is the like of mine plays, then this is well known, man!"

"What sort of speculations are you talking about? All the plays? But there's brilliant work in them. A lot of brilliant work."

Shakespeare eyed Gallatin with slight suspicion, then shrugged again, smiling briefly. "It seems thou hast some sympathy as an artist, after all. In truth, I have imagined tales both strange and wonderful. Tales of magicks, tales of wondrous strange creatures trafficking with men and women like unto ourselves, of other lands far removed in time and place from this our own. I have given words to heroes of legend, and recast legends to suit my fancies."

"Yet the histories are looked down upon, too?"

"Ah, yes," Shakespeare nodded. "Even there I framed events in such wise as to make them mine own, adding figures to the stage historical, all uttering such words as I wished them to speak. Yet this is not writing of worth, 'tis said. Not like my sonnets. In truth, some such plays met with the pleasure of the Court for obvious reason, but any writer must toil at commerce to earn the means to art."

"Yes, yes, I understand all that. Better than you know. But why haven't all your works been published?" Gallatin pressed. "Surely your critics don't control the presses."

"Why this question? Folios I have commissioned of *Lucrece*, and of *Venus and Adonis*. Both have seen several editions."

"I'm sorry. I mean your plays. Why haven't they been published?"

Shakespeare shook his head wearily. "Thou still thinkest my plays deserve folios? Who would make purchase of such low art? Yea, with the masses, as I said, my plays find favor, and money enough in measure, but such labors possess little merit in the world's eyes. Why, the world would mock me should I commission folios of plays, and little profit would it avail me if attempted. Too few moneyed followers of low art have I to inspire printers to work on such speculation, too little chance of earning them the large sums they seek in return for their labors."

"You're a midlist author?" Gallatin grabbed at a passing tray, lifting a brimming tankard of ale and hastily drinking the bitter, warm fluid. "They won't publish play folios for you because they wouldn't sell enough copies?"

"Midlist? More outlandish words, sir? But as for the rest, yea, even in my finest poems I am no Edmund Spenser nor Philip Sidney, men blest far more than I by those who claim to weigh artistic

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merit. So the gentlemen and their ladies make purpose to purchase their works, and so those authors prosper in relation."

"I didn't understand anything," Gallatin noted bleakly. "Only a few centuries past, in a similar society which even spoke basically the same language, and I didn't understand what happened, or why, or what it was like. I depended on secondary sources, popular accounts and my own preconceptions."

"In like manner I understand nothing of your speech," the playwright noted archly. "Have done, or tell in what wise thy words claim interest."

"Because I write about the future. I imagine what may happen in years to come. I'm wondering, though, if I didn't really know about the past, just how good were my speculations on the future?"

"A man need not know from whence he came to see whither he goes, but he hath no knowledge of the meanings of his travels if he sees not the whole."

"Damn." Paul Gallatin stood, shaking his head. "You do say things better than I do. Thank you, William Shakespeare. My old English teacher was right; you do have a lot to teach a writer. Of course, I don't think she ever expected me to get a personal lesson."

Shakespeare smiled as if amused. "If so, such is the last lesson for any soul from my tongue. As I have told thee, my poet's life is done, my foul papers left to whatever fate time may grant."

"Because you don't think of your plays as art, and don't consider them your property? And because you've sold the drafts of your poems and sonnets? So of course you won't mention any of it in your will. Thank you for your time and your words, sir."

"Words I have in plenty, though hence they'll bring me no more profit than any other man, nor more aggravation." Shakespeare laughed again as if sharing a joke with Gallatin. "Mayhap in some far future such as thou dreamest the fate of an artist will differ. How sayest thou?"

"I sayest thou shouldn't bet on it."

Ivan's grin didn't seem to have shifted during whatever time the journey had required. "Did you get what we need?"

"I'm afraid not." Paul Gallatin shook some foul-smelling London mud from his shoes, still wet with centuries-old damp. "Shakespeare's not a fake."

"The hell you say. Is there a bestseller in that?"

"There ought to be, but probably not."

The physicist smiled in commiseration. "Sorry it was a waste of time."

"Not at all." Gallatin smiled back. "Very inspiring, truth to tell, not to mention instructive. I've got a lot of reading and a lot of work to do."

"Reading? You're going to read Shakespeare?"

"Him and a lot of other old stuff I hadn't thought worth the trouble. I just learned they may have something to tell me after all."

"Ah, well." Ivanovich patted his machine. "I'm sure we can think up some other subject that'll generate a wildly popular book. Have you ever been to the Middle East?"

"The Middle East?" Gallatin questioned suspiciously. "Let me see those coins in your hand. They look...hell, they are Roman. That's Augustus. Augustus?" He fixed Ivanovich with a hard look. "You want one of us to visit the Middle East during the reign of Emperor Augustus?"

"Religious books are popular, aren't they?"

"Ivan?"

"Yes?"

"Don't go there." ■

Author's Note: *The author thanks Kage Baker for valuable information and suggestions on Shakespeare's life, times, and language, and takes sole responsibility for any errors that crept through anyway.*

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Tired

Michael Bishop

There's a fine line between "smart" and "smart-alecky" . . .

One morning, Gordon Pointer received an e-message from the left-front Goodstone tire on his old Callisto sedan. (He had bought the car used over a decade ago and retrofitted it for the intelligent interstates of the Piedmont metrosprawl.) Gordon abhorred palmflips, infraspecs, logomaniacs, microserfs, lapcops, and digital Kleenex, but he lived at the computerminal in his Callisto, journeying between office foci to talk with other human fossils like himself. He did not quail before occasional sitreps from his lead tire.

Intermittently, after all, Gordon also heard from the engine computer, the door locks, the trunk light, the fuel tank, and the brake drums, although seldom with such unobtrusive politeness as from Adam, the lead Goodstone.

<Gordon,> e-pistled Adam, <an internal sensor reading of my surface topography indicates alarming altitudinal decay and thus severe frictional reduction of my tread. In short, the highways and your admirable attachment to them have worn me down to narrow fraying belts, the perilous smoothness of a baby's bottom. You should replace me, Gordon, and soon.>

Unlike the archsurvivalist computer HAL in an old Kubriflick, Adam *sought* his own removal, junking, and replacement. In this brave new century, technology had acquired not only smarts and self-awareness, but also a type of self-abnegating helpfulness—altruism?—that often boggled its human beneficiaries. Gordon did not want to junk Adam. He *liked* Adam. Besides, to purchase four brand-new Goodstone tires in this age of labor-dictated moratoria and management-production shortages, would cost a healthy—no, a debilitating—seven thousand omnidollars.

Driving toward Brasstown Bald for a summit with MultiPrinz & Stru's CIO (chief itinerant officer), Samantha Gams, Gordon e-sent his lead tire this reply:

<How many kilometers you do you and your mates have left in you, Adam?>

<None.>

<None? You're jiving me, right?>

<You've ignored a dozen warnings, Gordon, each one more tire dire than the last. I could shred and pavement-plow you at any moment. So could Beatrice, Charlie, or Doreen. Stop or die. Go to the nearest Goodstone dealer and swap us out for a brand-new set, an Alice, Bob, Carol, and Danny, say. My next e-pistle could end in mid-sentence.>

This prophecy scared Gordon. He braked—carefully—and halted at the base of an incline for runaway forty-two wheelers. Then he stepped out to examine his Goodstones for himself. A flock of ruby-throated lizards whirred up from the gravel and swarmed into the dead loblollies picketing the hillside. The sky shone a clear headache green free of fluorocarbon and dietary-product-extract pollutants; in fact, this faintly throbbing antihistamine atmosphere confirmed Gordon in his decision to keep traveling

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as TyrannoCorps's southeastern sales rep. He breathed painfully and held one fist against his chest to prevent a cough—anything to keep the ruby-throats from whirring *en masse*, again, through the evergreen stumps and tall slate stalea.

Other travelers passed the Callisto without slowing their autopiloted conveyances; they rarely even cut their eyes to assess the antiquity of the sedan, which Gordon had bought because it ranked among the world's least frequently stolen vehicles, just behind Yugos and motorized rickshaws.

Kneeling at each corner of the Callisto in turn, Gordon looked over the treads of his Goodstones, which the dealership had installed when his odometer read 386,472 kilometers. (A Y2K-related glitch, along with a later conversion from miles to kilometers, had surely understated the extent of the tires' wear and tear.) On each tire, a thin gray crosshatching existed where firm synthetic rubber should have appeared; indeed, an onion-skin transparency showed where hard black ridges should have bulked. Adam had not shitted him. Only luck had kept him from beheading, disemboweling, or castrating himself in a bangup road accident, for road deaths had risen every month since last year's Congressional ban on air bags and impact gels—after clandestine lobbying by auto makers and emergency-room managers.

On the e-pad on his left wrist Gordon keyboarded this message: <I guess I should thank you, Adam. So thanks.>

<What about me?> beeped Doreen on the e-pad's tiny screen. <I've got tread left, and lots of it. How can you even *consider* junking me along with Adam and his bald-treaded cohorts? Good resource husbandry demands a more rigorous assessment of every product before disposal. Think of the omnidollars you'd save by retaining me for another three thousand kilometers or so.>

Aloud, to no one in particular, Gordon said, "Good Lord."

<Check me out,> e-nunciated Doreen. <Come back around here and check me out again.>

Gordon sighed and schlepped around the Callisto to reexamine his right-rear Goodstone. Another truck train whooshed by, rippling his topknot and his slitted tunic, but, retaining his balance, he noticed that Doreen did in fact look less ground down and deteriorated than her mates. Hmm. An anomaly, given that he had purchased and installed these tires at the same time—but *not* an unpleasant anomaly. Three replacements *would* cost less than four, and Doreen would helpfully signal her own hazardous degeneration before it fully endangered him, especially if he rotated her to Adam's supervisory slot.

<Okay,> Gordon e-told Doreen. <You can stay.>

<Charlie and I deeply resent the exception you intend to make for Doreen,> Beatrice e-zapped Gordon. <We came on as a team, we should go off as a team. Besides, the reduced wear evident on Doreen's tread derives from your own failures to check and repair this vehicle's wheel alignment and suspension system, not from any inherent superiority in her manufacture. Why should she benefit from your oversights and we other three suffer? Had you acted more responsibly, Gordon, we might all have lasted another five thousand kilometers.>

"Oh Lord," said Gordon aloud.

<You didn't rotate us as per the manufacturer's suggestions, either,> e-said Charlie bitterly. <I've spent my entire career as a load bearer and travel facilitator at this same left rear location. Even had you kept your car's chassis in good repair and the four of us in proper alignment, we *still* would have worn irregularly without periodic rotation.>

<Look, it wouldn't have made that much difference!> e-jaculated Gordon. <You all have finite lives as tires, damn

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it, and if you wanted quasi-immortality you should have petitioned Goodstone to fabricate you all as rocks!>

Another truck train blew past, rocking the Callisto on its quarrelsome bases. The sky writhed above the bowl of the hills like hot guacamole. Even as Gordon took a sliver of satisfaction from his sarcasm at the tires' expense, he regretted it. Arguing with the artifacts of post-millennial capitalism seldom redounded to the consumer's benefit. Far too many "helpful" products held grudges. In the end, they repaid you with shoddy performance, recrimination, even outright betrayal.

<You think yourself . . . such a wit,> Charlie e-said with cruel ellipses. <A regular member . . . of the Algonquin . . . inner circle. Well, Gordon, we . . . are . . . *not* . . . amused.>

Gordon looked about the in-leaning hills in resigned panic. He dared not climb back into the car to drive on to Brasstown Bald. First, his Goodstones had lost too much tread on thousands of rubber-laying trips on behalf of TyrraNoCorps Unlimited, and he could no longer trust them to transport him to his destination. Second, owing to this unexpected roadside debate and his scornful wisecrack, he could no longer trust them to deliver him to his destination. Someone unfamiliar with Goodstones might regard these two reasons as identical, but they diverged in a subtle way that heightened Gordon's alarm. He yanked his valise from the backseat, locked the sedan's doors, and began walking.

<I'll sue!> Charlie e-shouted. <I'll engage a corporation attorney to slap you with a multibillion dollar proceeding for abuse and, neglect!>

<I'll join him!> Beatrice e-promised. <You never maintained us very well, but I never thought you a *calculating* scoundrel!>

<Until now!> Doreen e-said. <And I've got a lot of travel in me yet! I'll sue you for ecological indifference, alienation of affection, and outright abandonment!> There followed on Gordon's e-pad a series of pound signs—<#, #, #, #, #, #, #!>—indicative of either weeping or unconstrained rage.

In the green day, Gordon hiked up the median between the road and the shoulder of the runaway-truck incline. He regretted not only his wisecrack but also his abandonment of his otherwise reliable automobile. The Callisto had not e-messaged him from its engine computer either a farewell or a reproach. Only his blasted tires continued communicating, overloading the screen of his wrist receiver with whiny maledictions.

Several yards from the summit, Gordon unsnapped the e-pad and prepared to hurl it across the highway into a declivity of purple sweetgums and gnarled loblollies. A glance at the tiny device halted him, for its screen was blinking at him with an almost wistful shimmer.

<Goodbye, Gordon,> e-said Adam, ostensible speaker for the Goodstones. <I've enjoyed the opportunity to serve you.>

Gordon tried to thank Adam for this sentiment, but Beatrice, Charlie, and Doreen all weighed in, simultaneously, with competing rebukes, contradictions, and curses, all of them brief and hard to read. Gordon muttered an imprecation of his own and flung the e-pad into the shadowy ravine across the road.

Coda

That spring, on his apartment balcony, Gordon showed Samantha Gams a small garden in the center of a used tire. This makeshift planter boasted lamb's ear, salvia, zinnias, and radiant orange Mexican sunflowers.

"They're awfully pretty," Ms. Gams said. "They'd look better, though, if you'd planted them in a window box or some terra cotta vases."

"Well," said Gordon, reminiscently gripping his left wrist, "that's certainly one way to look at it."■

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NEW IMPROVED WORMHOLES

Would-be wormhole engineers face the challenging problem of how to stabilize a wormhole, a topological shortcut from one part of the universe to another. Wormholes have a strong tendency to pinch off and disappear. It is well established that a sizable quantity of negative mass-energy is needed to overcome this tendency. That requirement has been perceived as a "showstopper" because our universe does not seem to contain "exotic matter" objects with negative masses. The only known way of producing negative mass-energy in the laboratory, the Casimir Effect, can only make it in exceedingly tiny quantities.

However, Sergei V. Krasnikov of the Central Astronomical Observatory in Pulkovo, Russia, using Einstein's general theory of relativity, may have found a way around the negative energy problem. (For a discussion of earlier work of Krasnikov, see my column in the September 1997 *Analog*). Krasnikov has devised a new class of wormholes that have the unusual characteristic of "puckered" throats. He has shown that for these wormholes, the negative mass-energy needed for stabilization is supplied solely by quantum fluctuations of fields in the vacuum. Thus, these wormholes need no "exotic matter" for their construction. His calculations indicate that it may be possible to construct a large transversable wormhole using only normal positive-mass matter and fields.

To understand what Krasnikov has accomplished, let us start with a review of the history of wormholes. For more than 80 years, Einstein's general theory of relativity has remained our "standard model" for gravity. In 1935, Einstein and his colleague Nathan Rosen discovered that implicit in general relativity is a tunnel-like structure in the topology of space-time, which we now call a wormhole. The mathematical equation (or "metric") of a wormhole describes a curved-space object that is a shortcut through space-time itself. A wormhole may connect two regions of space-time in the same universe (or can even connect two separate universes).

In principle, a wormhole can also make a "timelike" connection between one time and another in the same region of space, so that it becomes in effect a time machine, allowing communication and travel between the past and the future. However, some wormhole theorists, including Steven Hawking, have suggested that our universe may enforce a "chronology protection," with increasing vacuum fluctuations destroying any wormhole that is on the verge of becoming a time machine. These characteristics of wormholes were used in my hard SF novel, ***Einstein's Bridge***, in which alien-constructed wormholes were used for interuniverse communication, transport, and ultimately for destroying and "rewinding" our own universe back to 1987.

The mathematical possibility that wormholes may exist, implicit in Ein-

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stein's equations, raises a number of interesting questions:

•Are there classes of wormholes that are "stable"—that continue to exist for extended time periods?

•Are there classes of wormholes that are "transversable," in the sense that light or matter or even people could pass through them?

•Do natural wormholes exist, and if so how can we find them?

•Could artificial wormholes be produced, and if so how can we make them?

•Could wormholes be used for faster-than-light (FTL) travel and/or for time travel?

Not all of these questions can be considered here, but all of them have been at least partially addressed in several of my previous columns (see my *Alternate View* columns numbers 33, 39, 53, and 69, published in *Analog* in the June 1989, May 1990, July 1992 and mid-December 1994 issues).

If wormholes are to be used for FTL communication or transportation, the issue of stability is an extremely important one. In the 1950s Wheeler and Morgan demonstrated that Einstein-Rosen wormholes (or "bridges") are extremely unstable, so that if such a wormhole should happen to appear spontaneously it would pinch off so rapidly that not even one photon of light could pass through it before it closed.

In 1988 Michael Morris and Kip Thorne of Cal Tech showed that stable wormholes are possible after all, and they described how a stable wormhole might be constructed by an "advanced civilization" (i.e., not us). They found that to stabilize a wormhole, a region of negative mass-energy was needed in the wormhole's "throat." They suggested creating this negative energy region by using the Casimir effect, a quantum effect in which long-wavelength vacuum fluctuations are suppressed in a region between conducting surfaces. Morris and Thorne suggested creating the required region of negative energy by placing two electrically charged spherical capacitor plates in the curved space of the wormhole throat (with each sphere geometrically *inside* the other, and with the spheres spaced about a proton diameter apart!). Subsequent analyses showed that a Morris-Thorne wormhole would have to be of planetary dimensions, would require planet-mass quantities of negative mass-energy, and that the tidal forces created by the space curvature of the wormhole throat would be likely to destroy atoms (or people) attempting passage through it. Therefore, Morris-Thorne wormholes, while perhaps stable, cannot be considered to be transversable.

A few years later, Matt Visser of Washington University in St. Louis suggested a more user-friendly class of transversable wormhole. He describes his flat-space wormholes as produced by cutting holes in two separated regions of spacetime and then sewing the edges of the holes together with "cosmic string." In other words, two joined regions of flat space are framed by a loop of cosmic string of negative mass and string tension. The cosmic string (another exotic artifact of general relativity) provides the needed negative energy. However, it is questionable (a) whether cosmic strings actually exist in our universe, (b) if they do, whether they can have negative mass and string tension, and (c) whether the tendencies of the wormhole to close up and of the negative-tension cosmic string loop to expand could be precisely balanced to produce a stable Visser wormhole. Therefore, neither Einstein-Rosen, Morris-Thorne, nor Visser wormholes appeared feasible for FTL transport in our universe.

At this point let us inquire just what theorists like Einstein, Thorne, Visser, and Krasnikov are doing when they use mathematics to design a wormhole. General relativity provides us with a procedure for designing a wormhole (or

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any other space warp) by following these three steps:

1. Describe the kind of space-curvature that is desired by using a "metric," a symmetric 4 x 4 matrix that is a mathematical description of curved spacetime.

2. Solve Einstein's equations for the "stress-energy tensor" (a mathematical description of how mass-energy from matter and fields is distributed in space), such that the stress-energy tensor will produce the desired metric.

3. By successive approximations, find a configuration of matter and fields that will produce the required stress-energy tensor.

That's all there is to it. However, while many wormhole theorists have been able to carry out steps 1 and 2, the problem lies in accomplishing step 3. Einstein's equations tell us that the stress-energy tensor needed to produce the metric for wormholes (and other space warps like "warp-drives" that are of interest to SF readers and writers) requires a large quantity of *negative* mass-energy that must be concentrated in a very small region of space. This violates what theorists call the "Weak Energy Condition" and has been viewed as requiring the existence of "exotic matter" having negative mass-energy. Unfortunately, all the matter and fields of our acquaintance have positive mass-energy. There has been a growing consensus among physicists that the requirement of negative mass-energy makes it impossible to construct a wormhole with normal matter and that some "exotic" material like Visser's negative-tension cosmic string would be required.

However, this consensus may be wrong. Krasnikov has shown a third way of obtaining the negative energy needed to form a stable wormhole. He demonstrates that the fluctuating energy of the vacuum itself can be used as the source of negative mass energy, so that the wormhole that can be constructed with only normal matter and fields.

Empty space, according to quantum mechanics, is not static and unchanging, as one would naively expect. As the quantum vacuum is examined microscopically at smaller and smaller distances, it is found that virtual particles with both positive and negative energies spontaneously appear and then disappear, their brief period of existence governed by Heisenberg's uncertainty principle. Krasnikov's calculations indicate that the negative energy part of this process is useful for wormhole engineering.

Krasnikov separated the stress-energy tensor, developed in step 2 above, into two parts, one part from the mass-energy of quantum vacuum fluctuations and the other part from the matter and fields that form the construction materials of the wormhole. He performed "heroic" calculations with a fast computer using the large numerical relativity program *GRTensorII*. From these calculations he demonstrated that for his particular kind of puckered wormhole, the second part of the stress-energy tensor (the non-quantum-mechanical part) has positive energy and therefore can be produced, at least in principle, using only ordinary matter and fields. Moreover, he has shown that there is no particular size limitation to the new class of wormholes, and that they could be made as large as is needed.

It is not clear from his publications whether Krasnikov has actually evaluated the quantum mechanical part of the stress-energy tensor. However, it appears that for the new class of wormholes the requirement for exotic matter seems to have been eliminated, with the quantum vacuum itself providing the negative energy contribution from quantum fluctuations of the electromagnetic field, the neutrino field, and the massless scalar fields (as predicted by some theories).

The metric of Krasnikov's new wormhole has a very simple mathematical

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form, a simple four-term equation. However, the curvature of space in the throat of the wormhole is peculiar. It is wrinkled or puckered like crepe paper, folded into sine-wave rings from the center to the edge to make a sinusoidally varying space warp. Krasnikov has not reported the results of step 3 of the procedure above, so we do not know what configuration of matter and fields might be needed to produce this metric. In particular, we do not know whether the needed matter densities and field strengths lie within the ranges of what is currently feasible.

These "engineering details" need to be worked out. Even if only normal positive-mass matter is required, it may well turn out that Krasnikov wormhole can only be built out of "unobtanium." Also, the tidal forces from the space curvature and gravitational field gradients in wormhole throats need to be examined, to determine whether a space traveler passing through a wormhole throat of reasonable size would have a chance of survival. Moreover, Krasnikov's calculations and assumptions need to be verified by other relativity theorists. In particular, it is well known that calculations of the mass-energy of quantum vacuum fluctuations are tricky, and that results can be wrong by many orders of magnitude. It is important to verify that Krasnikov has avoided this pitfall.

Nevertheless, an important step has been made in the theory of wormholes. It has been demonstrated that stable transversable wormholes constructed from normal matter are possible, at least in principle. The details remain to be worked out, but we have the beginnings of the new art of wormhole engineering. ■

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The attempt to combine wisdom and power has only rarely been successful and then only for a short while.

-Albert Einstein

Those who begin coercive elimination of dissent soon find themselves exterminating dissenters. Compulsory unification of opinion achieves only the unaimity of the graveyard.

-Felix Frankfurter

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Funny Furry Fellows

Mia Molvray

Beware of projecting your own traits onto others . . .

Narita was lying on a hill with her dearly beloved Charles when she felt the earth move. Always one to see the humor in any situation, she let out a stifled chuckle even now, but she knew this was not good.

"What's the embassy up to?" she asked her lover. She was petite, pixie-faced and black-eyed, with a smile that turned her lips up in a V. She was a painter of watercolors. The embassy did not take her seriously, but the feeling was mutual. Charles was a young man with well-groomed hair, a straight nose, a square jaw, and an inscrutable expression suitable for a budding diplomat—except when he looked at Narita. Then hidden thoughts winked in the depths like invisible fish catching a glint of the sun. He worked at the First Clayocluuret Diplomatic Delegation and Contact Team. The long name lent importance to the mission. Unfortunately, since it was not backed up by money, it did not lend very much.

"I'm just the deputy associate linguistic liaison to the consular secretary, fuzzy-wuzzy. They don't include me in their plans."

She smiled at him. She liked being called fuzzy-wuzzy. "Yes, but what do you think?" she persisted. "You know the Cluuries. They'll laugh 'till nightfall trying to play tic-tac-toe, yet the embassy keeps getting them mad enough to do that mountain-moving trick of theirs."

Charles raised his eyebrows for a look of wonderfully professional detachment.

"Have you been practicing that?" she demanded before he could answer, her smile now quirked into glee.

"Of course," he said unhesitatingly, a faint ghost of her sense of the ridiculous flitting over his face. "I bet they tried another illicit mining operation which is being buried as we speak. His Excellency the Ambassador seems to be a slow learner."

Of course he was, Narita thought. He took his job so very seriously, yet any passing painter could see that the whole mission was simply an advance guard for the well-connected toffs. *They* would sign the actual agreements and bask in the actual credit.

"Titanium and yttrium and god-knows-what-all," she said dreamily, "buried in dunes all over the planet. But it's more beautiful as flowers." Spring rains had changed the dry, dusty sand of Clayocluuret into sky-blue pools surrounded by red, yellow, blue and white flower meadows. "Besides, I'd poke the ambassador in the ribs too, if I had to talk to him."

Narita, following Charles, had been at the mission right from the start. She'd been there when people thought the na-

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tives could be bought off with beads. Although intelligent, the natives showed no signs of knowing how to do anything but float about in the pools and catch insects, their staple diet. They were bipeds the size of a ten-year-old, tubby, and furry even on their toes but not on their heads. They were placid and jovial. The situation seemed perfect.

However, as happens so often in life, the situation was far from perfect. Narita had been there when it dawned on people that the natives wanted a cut of the profit. This was not immediately obvious because the natives' notion of negotiation included standing on their heads and wiggling their furry toes or tickling the ambassador and then rolling about on the ground making a whistling sound with their wide mouths extended into a tube ending in a small "o." All the staff, including Charles, had scoured the countryside for more "responsible" natives. When they finally found a few and began serious negotiations, the ring of locals rolling on the ground and whistling became so thick that the ambassador insisted the talks be moved indoors, despite the Cluuries' dislike of enclosures.

Like all beings with well-developed sitting muscles, the serious Clayocluurians did not generate any actual results but at least the ambassador seemed to feel better. Besides, so long as he was negotiating and thereby demonstrating good faith, he said nobody could fault the humans for proceeding with some prospecting. Narita was convinced that "nobody" in this case did not mean nobody, but only that small subset of bodies including the Ambassador's superiors.

The first landslide to engulf a mine was assumed to be a natural event. Maybe wind had somehow blown in an astonishing amount of sand overnight. The next one appeared to be a bizarre coincidence. Maybe wind had blown in an astonishing amount of sand *again*. The third one had people throwing salt over their shoulders and nailing plastic horseshoes over their front doors. (Iron was hard to come by on Clayocluuret.)

The mission's geologists studied the marching dunes to exhaustion, with no result. Of course, the scope of their questions was limited by the ambassador's edict that "nonsense" would not be reimbursed. Nonsense included anything connected with the Cluuries, which, as happens so often with funding, directed the research into channels the administrators could understand. Narita mentioned her ideas about Cluuries and dune-moving to anyone who would listen—out of the Ambassador's earshot—but only the newest geologist, Evelyn Frobisher, paid any attention.

"I have family in New London," Evelyn told Narita quietly at lunch one day, "so it looked like a call home. I had Arvidjian himself on the line—" Narita knew he had worked out the equivalence of thought and energy, much as an earlier genius had understood the relationship of energy and matter—"and *he* said they were probably entwining particles. He said it was a good test for his theories. He said more research needed to be done." Evelyn looked thrilled.

Narita looked blank.

"They must condense thoughts to energy," Evelyn continued, "and probably to particles, entwined quarks most likely. They could affect the distant member of the pair, then release the energy and reabsorb as much as they could for the next go-round. Just think of the energetics! There really is so much research that needs to be done on the system," she repeated happily.

Narita left her with visions of high-level collaborations and funding dancing in her head.

When Charles asked the negotiating Cluuries about moving dunes, they squirmed uncomfortably in their seats and wrung their furry toes feverishly since their short legs couldn't reach the floor. Yes, they intimated, "others" were capable of that sort of thing.

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The ambassador sniffed with exaggerated patience when Charles brought him the information. "My dear boy," he said, "it's the oldest trick in the book. Insist on compensation or you'll use your great magical powers. The Cluuries' idea of high technology is floating on a log instead of swimming and you're suggesting they move mountains. By what means? Humming at them?"

So the humans kept trying new mines, the Cluuries kept burying them, and the negotiators kept negotiating. There was potential for lifetime employment for all concerned.

Nothing stays the same for long and the situation changed even as Charles and Narita sat on their unquiet dune. The radio in the flitter parked behind them crackled to life.

"Hoy. Whittington. You there?"

"All present and correct," Charles called back to Jamie Olongwethi, an equally junior aide with whom he formed that mutual support society characteristic of intelligent underlings.

"Well, you and your infinitely better half need to beetle back here. Things are happening."

"Um," grunted Charles, standing up. "Things are happening here too. What things?"

"I think the Cluuries are trying, in the nicest possible way, to tell us they are really annoyed. They're burying the embassy."

Charles and Narita stared at each other with widening eyes, flung themselves in the flitter and shot back to the embassy.

It was not particularly grand as embassies go. It was prefab and looked like a giant shoebox with windows, but it was three stories tall and it bristled with transceivers on the roof. Right now the transceivers were overshadowed by a massive dune much too peaked at its leading edge. Arms of the dune reached toward the sides of the building, barely a stone's throw away, as if the whole shoebox was about to be carried off by a beige wave.

The flitter's receiver suddenly came to life with the harassed features of the Ambassador's senior aide.

"Whittington!"

"Right here, sir."

"Watch where you land. Stay out of the laser beams."

"Laser beams!" But the aide's image had already disappeared.

Charles and Narita searched frantically. Out front were tens of evacuated embassy staff fluttering fitfully about, but lacking the purposeful panic of trained diplomats under fire. Out back were six Cluuries scattered some distance from the dune, calm as sunbathers. Narita exclaimed, "That's Feather Toes!" He was one of her special friends and had even held brushes for her on occasion as she painted her landscapes. He'd also used the opportunity to paint designs on her trouser leg.

Then Charles and Narita spotted two mining lasers pointed at the dune, small from the air, but huge on the ground. Then they understood.

"Jumping jam jars," muttered Narita, "they're going to try to melt the dune. Pinheads. Dingbats. Wingnuts."

As they neared the embassy, one leg of the tripod holding up the furthest laser suddenly sagged. Its lethal beam arrowed up into the sky, its operator floundered briefly in the quicksand, and the machine settled into an ineffective attitude. He had it righted in another moment, but then the other laser developed the staggers. No sooner was that one sorted out, than the first one flopped in a new direction. Back and forth, like two expertly handled puppets, the two operators took turns jerking at their machines. The sunbathing Cluuries watched appreciatively, moving their heads to follow the action as if this was a new form of tennis.

"Of course," cried Narita, "*they're* doing that!"

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Charles refused to be distracted by these side issues. "Why is a burning embassy better than a buried embassy?" he muttered. "It's not like the Cluuries are pushing with their furry fingers and will quit when it gets hot."

"My paintings could have been unburied if they'd just left it alone," Narita realized as she stared at the third floor window which was their room. "But unburned? No."

"Oh, dreck. Your paintings! We better get them."

Narita shook her head decisively. "Don't even dream of it. You'd get fired. Besides"—the dune was glowing red—"if that starts to flow and reaches the building before we can get out—."

"I'm absolutely positive the Cluuries control the dune movements completely. They won't do anything if you're in there."

The receiver crackled.

"Whittington!" It was the ambassador's aide again. "Who are you trying to impress? The dune is at 1500° and rising and the damn thing's still moving. The building's going up any minute. Get your brainless behind on the *ground*."

Charles quietly turned off the comm.

He pushed the flitter to its limit and vectored in toward the embassy's roof. Narita stared at him, hoping he was as good a pilot as he thought he was.

"Now we get to see if that monster holds off long enough for you to run in," he muttered.

It was a glowing red wave, still moving forward too slowly to stop fast.

"I don't know, Charlie—" Narita was torn—"they're just paintings—"

"They're your work," he said as if that ended the discussion, which it did because they had touched down on the roof.

The forward flow of dune lava stopped. Its top shifted backward like a wave suddenly hit by oncoming wind.

"Awww," murmured Narita as the hatch started to open, "you probably hurt its feelings by calling it a monster."

She lunged toward the door to the stairs leading down, but two hefty embassy guards cleared the edge of the roof, each maneuvering their jet lifters with one hand and holding a steady stunner in the other.

"Hold it, you two," the senior one barked.

"Shi—" Narita began when loud yelling erupted below in the vicinity of the lasers.

The guards lost their focus.

One glance over the edge showed the two machines beyond control, pointing at each other while their operators dove for cover. The Cluuries were whistling quietly in the distance. Narita completed her lunge for the door.

Moments later she was back, panting, her portfolio under her arm. Charles was being held, literally, by the two hefty guards, one at each elbow. They looked grimly pleased to be holding *someone* in all this aggravation. Narita thought a few Clayocluurians would be very useful about now to tickle the long arm of the law.

"Look, I insisted," began Narita, "and I was piloting," she added quickly.

The imperturbable expression on Charles's face became a shade more imperturbable. Good, thought Narita, that's what he's been telling them. "And anyway, you're too busy being pleased with yourselves to get the point," she continued recklessly. She'd almost lost her life's work, her lover had risked life and career, and she was in no mood to tread lightly around martinets who doffed their brains when they donned their uniforms. "The *point* is that the dune isn't moving while we're up here."

This was not strictly true. The lethal heap of lava was slowly backing away.

The two stolid soldiers barely looked at her or the flowing, fiery rock. "We have our orders, ma'am," they said together, but then their comm boxes squawked.

The supremely exasperated voice of the ambassador himself came on. "The

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dune no longer appears to be moving. The fuzzballs are covering the melted part with fresh sand by staring at it." The admission appeared to hurt him. "And now Harpo here says he'll talk to Twinkle Toes!"

Narita's eyes widened but she recovered quickly. She was always calling the natives this-toes and that-toes because of their wonderfully furry feet. Once, as she was painting a pool and watching the furry fellows frolic, one of them suddenly asked her across the language barrier why their names in her language all referred to toes. The danger of causing an interplanetary incident with her facetiousness (something Charles said was bound to happen sooner or later) brought her up short. It was a custom in her family, she said quickly. Her own name was Twinkle Toes.

Charles landed the flitter near the ambassador, while the guards jetted importantly alongside. It turned out to be Feathery himself who wanted to speak to Narita.

"What for they clog our pools?" he asked.

Charles translated, but before Narita could answer, His Excellency took over. The boiled look in his eye said that this was no place for amateurs who had no notion of building words into a dam against rivers of glass.

"We have been on excellent terms and look forward to a long history of cooperation between our peoples. What point is there in destroying our mutual spirit of harmony by what amounts to vandalism?"

Narita knew enough Clayocluurian to hear Charles translate: "Why are you burying our embassy?"

"Why not?" inquired Feathery with all possible blandness. He turned back to Narita and repeated, "What for they dig our sand?"

Narita opened and shut her mouth a few times feeling a bit like a carp out of water. Her first impulse was to say, "Because they need a sandbox," but she couldn't help feeling sorry for the slowly swelling ambassador.

"I, uh, don't really know." She found herself thinking that if the ambassador swelled much further, someone might get the idea of using the final explosion to blow back the dune. "I don't know," she repeated much more firmly. "All I know is the government wants your minerals so they sent out a junior crew of people"—the ambassador turned a delicate shade of purple—"to make whatever mistakes there were to be made. They could fail and be demoted without major repercussions"—the ambassador's purple deepened—"and the more senior crew they sent next could use the information to negotiate a contract more quickly."

"Minerals?" asked Feathery Toes. "What for minerals?"

"Computers," answered Narita, "and medical machines and spaceships."

"It allows people to see funnies," said Charles with the acumen of a true diplomat. "See?" He unlatched his computer from his belt and started an old film running. "Steamboat Bill, Jr." the hologram said, "by Buster Keaton."

The natives settled down to watch once they realized that trying to tickle the serious, miniature Keaton would have no effect.

"Whittington," said the ambassador severely, "this is neither the time nor the place. We're in danger of being wiped out. Get them to pull back. Then we'll talk."

"Yes, sir," said Charles evenly, with no visible effect on the course of the film.

The ambassador appeared to be on the point of exploding, but suddenly contained himself when he noticed a Cluurie out of the corner of his eye, imitating his every move with the uncanny accuracy of an irritating ten-year-old.

"It is good you have other grownups," said Feathery, pointing at the hologram and whistling in obvious enjoyment.

"Other grownups?" asked Charles, bewildered.

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"Yes," Feathery agreed, misunderstanding the question as a statement. "That is good use." He nodded at Keaton tilting against the hurricane as the front wall of a house fell on him and neatly framed him in a providential window. "You may use some of our sand for 'funnies'. We will say where."

The ambassador suddenly lost interest in his dune-halting agenda and interrupted to take advantage of this new state of affairs with his usual adaptability, drive and initiative.

"It gives me great pleasure to see that our months of careful negotiations have led to understanding among all parties concerned. Of course, we realize there are still many details to be worked out, but at this point in time we can, I am sure, move forward once your committees have issued instructions to your negotiators, and—"

Feathery turned his back on the flow of words. "Usual is the whole pond decides together," referring to the groups favoring specific wet-season watering holes, "but you from far, so other grownups perhaps difficult." He looked at Narita and seemed to wait for confirmation, giving the Ambassador an opening he instantly used.

"And then we can work out the language for each—"

Feathery gave an odd shrug to his shoulder fur. "Good time to go 'negotiate' now," he suggested, pointing toward the knot of serious and embarrassed Cluuries who usually were called upon when negotiations were needed.

The ambassador had the incongruous feeling he was being told to run along, but local customs were often inscrutable and it wouldn't do to offend anyone at this delicate stage. He called over a more senior translator to accompany him.

Feathery seemed almost relieved. "Always a problem, at that age," he murmured at the ambassador's retreating back. Then he returned to his point. "More people difficult?" he asked Narita again.

"To bring more nondiplomatic nonessentials like me here?" asked Narita, casting about for what he could possibly mean. "Well-nigh impossible, I should think."

"Is all right," said Feathery reassuringly. "Your Big People do not need to send anyone older. You are old enough, Twinkle Toes."

"I'm not old," protested Narita.

"You did say someone more senior," muttered Charles. "How do you know she is old?" he asked Feathery.

"She is old enough to laugh."

"But children laugh too. More, if anything," said Charles carefully.

"Is it so among you?" Feathery Toes whistled in amusement, jumped and stood on his head.

Charles stiffened slightly.

"No," whispered Narita. "No, I think he just means we're a topsy-turvy species."

Feathery folded suddenly, rolled out of his headstand and jumped up before them. "Among us only children are serious. Anyone who knows anything about life has learned to laugh."

"But—then—" Charles glanced back at the ambassador talking to his little circle of Cluuries, now more earnest than embarrassed.

Narita glanced over too. The ineffectiveness of the ambassador's negotiations suddenly made perfect sense.■

Mere unorthodoxy or dissent from the prevailing mores is not to be condemned. The absence of such voices would be a symptom of grave illness in our society.

— Earl Warren

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KADDISH FOR THE LAST SURVIVOR

Michael A. Burstein

Understanding the past is important to shaping the future—but that requires the gut-level understanding that the past was real.

"The deniers' window of opportunity will be enhanced in years to come. The public, particularly the uneducated public, will be increasingly susceptible to Holocaust denial as survivors die . . . Future generations will not hear the story from people who can say 'this is what happened to *me*. This is *my* story.' For them it will be part of the distant past and, consequently, more susceptible to revision and denial."

— Deborah Lipstadt,
Denying the Holocaust (1994)

Sarah Jacobson's hands shook as she parked her clunky Volkswagen across the street from the old suburban house in which she had grown up. She sat there, breathing in the gas fumes from the idling engine, as she watched the reporters swarm all over the front lawn.

Her boyfriend, Tom Holloway, sat next to her in the passenger seat. He stared at her for a moment, then asked, "Ready?"

Sarah nodded. As she turned off the car's engine, Tom jumped out of the front seat, dashed around the front of the car, and opened the driver's side door for her. For once, she was grateful for the old-fashioned Southern charm. To think when she'd first met him, she'd resented it.

Well, she didn't resent it now. Tom was positioning himself to fend off the horde of reporters, and she was grateful for that too. Fortunately, no one had noticed, or else they had not yet connected Sarah to the biggest news story of the week. Tom gave Sarah his hand, and she allowed him to help her out.

She stretched as she got out of the car, feeling the warmth of the spring sunlight on her back. How strange that she could enjoy it, on this morning of all mornings. She closed her eyes and took a deep breath, listening to a bird singing in the distance.

Tom's voice intruded upon her brief peace. "Shall we?"

She gave him a small smile. "I guess so."

"OK." Tom looked around, concen-

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trating his gaze at the sea of reporters. "Lot of excitement for a small town on Long Island," he said. Sarah noticed that he was making no effort to suppress his Southern accent; he knew how endearing she found it. "Hard to believe your grandfather's attracting all this attention."

"Yeah," Sarah replied. "I know." She cocked an ear toward the reporters. "Listen."

One radio reporter, close enough to be heard, was speaking into her thumbnail recorder, taping commentary for her story. "This is Paula Dietrich, reporting from Lawrence, Long Island, where Joshua Cohen is dying. Born in Warsaw in the 1920s, Cohen—"

Tom whistled. "He's become a celebrity. Finally got his fifteen minutes of fame."

Sarah shrugged. They'd both studied Warhol. After all, they had both graduated from Harvard with honors. "As far as I'm concerned, he's just my grandfather."

"Yeah, I know," Tom said softly. "Sorry. You sure you're ready?"

"Ready as I'll ever be, I guess. If I can survive this, I can survive anything." Sarah grabbed Tom's hand. They walked off the sidewalk onto the path leading up to the front door. She braced herself for the barrage.

One of the reporters glanced in their direction, and recognized Sarah. "It's the granddaughter!" he yelled, and began running towards them. In seconds, all of the shouting, sweating journalists had descended upon Sarah and Tom. The way they jostled at each other, trying to get better positions for recording their images, reminded Sarah of a plague of locusts come to feed.

"We'd like to ask you—"

"May I ask you—"

"I have a question—"

"How do you feel?"

"Did you ever think—"

Tom shouted above the Babel of voices. "Please, everyone! Sarah just wants to get inside."

Obviously that was not good enough for the reporters. Instead, they used Tom's interruption to create some semblance of order to their questioning. One reporter took the lead, and the others fell silent.

"Ms. Jacobson, Trevor Hunt, *USNA Online*. Could you tell us what you're going through at the moment?"

Sarah glanced at Tom and shrugged. It would be easier to answer a few of their questions first, she decided, and then go inside. She looked directly into Hunt's right eye, which glowed red with the lens of an implanted camera. "What anyone would go through when her grandfather is dying, I guess."

"But, Ms. Jacobson!" interjected the radio correspondent they had been listening to earlier. "The circumstances of your grandfather's position—"

Sarah interrupted her. "Listen. I know what my grandfather is to the world, but to me, he's just my grandfather. Now let me go say goodbye to him in peace. I promise I'll talk to you—all of you—later."

Apparently chastened, the reporters parted in front of Sarah and Tom, clearing the path to the front door. As they walked up the path, a background murmuring began, like cats growling at each other over their food. The reporters chatted with their colleagues or recorded views for their broadcasts. Tom whispered to Sarah, "I'm really surprised. They're being more courteous than I would have guessed."

No sooner had Tom said that than a small man stepped right in front of them, blocking their way. He brushed back his sandy blond hair and asked, "Ms. Jacobson, why does your family continue to perpetrate this hoax?"

The growling noises of conversation cut off, leaving nothing but the sounds of the cameras and recorders.

At first Sarah thought he was a private citizen, and not a member of the media, as he carried no recording devices and

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his eyes appeared normal. But a second glance exposed something far more sinister. This man wore a memory recorder implant behind his right ear. His audience, whoever they were, would be able to directly interface with his memories of confronting Sarah, over and over again.

As calmly as she could, Sarah said, "Excuse me?"

The man smiled. "I asked, given the fact that your grandfather, who lived a long and healthy life, is now on his deathbed, why does your family feel the need to perpetuate the hoax of the Holocaust?"

Tom stepped forward, shouting, "Now, listen here, you—"

Sarah gently reached out and grabbed Tom's shoulder. "Tom, stop." She turned to the man. "Excuse me, but I didn't catch your name."

"Sorry. Maxwell Schwab, from the Institute for Historical Revision. I'm doing an article for our academic journal." He waved his hand at the other reporters. "We'd like to know why your family has gone to the trouble of inviting the mass media here, pretending to the world that the Holocaust actually happened and that your grandfather was a victim of this fictional event."

Tom pulled at her arm. "Come on, Sarah, we don't need to listen to this shi—this crap."

Sarah resisted. "No, wait." She pivoted her body to face the reporter. "Mr. Schwab?"

"Yes?"

Sarah slapped him on the face, hard, glad she'd studied self-defense. He staggered back, and fell onto his backside. Sarah hoped it was painful enough to keep people from playing this memory.

Schwab sat there, unmoving, just staring at Sarah. No one bothered to pick him up.

She turned to Tom. "*Now*, let's go inside."

No one else stopped them.

* * *

The first thing that hit Sarah as she entered the house was the smell. The odor of stewing meat and potatoes from the kitchen mixed with the old, musty smell that the house always seemed to have whenever Sarah had returned from college. The living room seemed dark, and it took her a moment to realize that all the shades were drawn, probably to keep the reporters from looking in.

She called out to her parents. "Hello? Dad? Mother?"

Her father called back, "In the kitchen, honey, be right out."

Sarah turned to Tom. "Are *you* going to be OK?"

Tom smiled, shrugged, and took Sarah's hand briefly. "Yeah, I've dealt with her before. It's not too bad."

"She's not *your* mother, though."

The door to the kitchen swung open. Sarah's parents, Paul and Anna Jacobson, entered the living room. Her father looked calm, cool, and collected, the way that he always looked. He wore a jacket and tie, in stark contrast to the polo shirts and jeans which Tom and she were wearing. Sarah couldn't remember a time when her father wasn't dressed so impeccably. Her mother, on the other hand, wore a sweatshirt and sweatpants, as if dressing well was currently her last priority. She appeared frazzled, with her hair all askew.

Tom greeted them with a simple hello. Sarah's father smiled at Tom, but her mother barely glanced in Tom's direction.

There was a moment of silence, which her father broke. "Come, Tom, I need your help in the kitchen. You can tell me how your family's doing back in Durham. And how about those Mets?"

The two men went through the slow swinging door, which creaked loudly until it finally shut, muffling their awkward conversation about baseball. Sarah and her mother watched the door for a few seconds after it had closed, and then Sarah turned to look at her mother. "I guess," Sarah said, "I ought to go up-

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stairs and see Grampa."

Her mother sniffed. "Sure, go ahead. Do you want to bring your *goyische* boyfriend upstairs too?"

Damn, Sarah thought, *she wasn't going to be reasonable. Surprise, surprise.* "Mother, please—"

"And now you're living with him."

Shocked, Sarah took a deep breath. "I never told you that! How did you find out?"

Her mother grinned. "Just now, Sarah. You may be my smart Harvard daughter, but you're not smarter than me."

Sarah felt furious, but more with herself than with her mother. Anna Jacobson had done it *again*, pretending to know something so as to trick the information out of Sarah. Damn! How could she have been so stupid? Well, as long as Mother had figured it out, Sarah might as well get everything out in the open.

"I was going to tell you anyway, Mother. Today, in fact. Tom and I are living together. We have been for a while now."

Her mother glared at her and Sarah said, "I don't care how you feel about it. And anyway, things are different now."

"Such defiance," her mother said, making clucking sounds with her tongue. "And things being different isn't an excuse."

"You're right, Mother," Sarah said as sarcastically as she could. "An economic depression is no excuse for being unable to afford my own apartment."

"Now, Sarah—"

"'Now, Sarah,' *what?*" Sarah slammed the doorframe with her palm. "It's not like you have the money to help out; you still live *here*, in the oldest house in the neighborhood. You can't even afford automatic doors. Well, I can't afford to live by myself. No one right out of school can, not with our loans. And as it is—" She paused for a moment, then took the plunge. "As it is, Tom and I will probably be getting married soon anyway."

There. The big secret was out. Sarah studied her mother's face carefully; it seemed completely shut down. Her mother just stared at her, stonily, not reacting. Finally, Sarah couldn't take the silence any longer. "Well?" she asked. "Aren't you going to say something?"

Her mother sighed. "Sarah, it isn't Tom. He's a nice boy, and I do like him. But I—and your father—would prefer that you marry someone Jewish."

"Why?"

"Why? What do you mean, why?"

"Exactly what I said, Mother." She spoke crisply, trying to imitate the Cambridge accent of some of her professors. "Why?"

Her mother looked over Sarah's shoulder. Was it possible she had never really considered this question before? After a few seconds, Sarah's impatience got the better of her again. "Is it because of Grampa? Because he's the last one?"

Her mother immediately replied, "No! It's because you're Jewish. And it surprises me you'd even think of marrying someone who isn't."

Sarah shook her head and sighed. "You know, Mother, you shouldn't be so surprised. You never raised me as Jewish."

Her mother's eyes, filled with shame and fear, locked onto Sarah's. "That's not true," she said softly.

Sarah nodded and went back to being sarcastic. "Yeah, Mother. Matzoh ball soup on Passover, and Chinese food and a movie on Christmas. Should have been enough for me, right? That didn't make me Jewish; it just made me a different type of American. And that's how you and Dad raised me, as an American."

Her mother stood still for a moment, then sank onto one of the cushioned chairs. It sighed, sending dust into the air. "I can't believe it," she said, shaking her head. "I'm doing what I said I never would."

Confused, Sarah asked, "What are you talking about?"

Her mother seemed to go through an internal struggle, and when she spoke next, her words were chosen with care.

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"Sarah, I guess you were right, in a way. It *is* because of Grampa that I want you to marry someone Jewish, but it's also because of Grampa that I never really made that clear. Because—because I wanted to protect you."

"Protect me?" Sarah felt surprised; the only things her mother had ever tried to protect her from were strangers and bad grades.

"Yes, Sarah, protect you. I mean, just look outside at that mob of reporters. You don't know what it's like growing up as the only child of a survivor. I had to grow up listening to all these stories over and over, all this pressure on me from your grandfather. Because of the Holocaust. All that pressure you're feeling from me—I felt it from him. He's dying now, and I still feel it." Her voice trembled, but she clamped her mouth shut.

"Because of the Holocaust? Mother, Grampa was never very religious; you told me that yourself. And I don't see how the Holocaust is a reason to marry someone Jewish."

"Why not?" she asked softly.

Sarah considered the question. "I know *something* of our religion," she said without conviction. Somehow, that was the one thing she had never gotten around to studying while at Harvard. "The Holocaust is not exactly a—a defining event in Judaism."

Her mother shook her head. "Oh, yes it is. After all, Sarah, by intermarrying, aren't you denying what it is about you that made the Nazis try to wipe us out? Some would say that you're letting Hitler win. After all these years."

Sarah didn't know what to say to that; it made her angry and upset, and choked her up. But her mother continued. "Sarah, these were all the things I had to grow up with from your grandfather. I don't know what it was like firsthand to be in the camps, thank God, and God forbid that anyone ever will again. But to your grandfather, his experience there was always more real than the rest of his life. More real than the people in his life."

Her mother paused for a moment, then said, "It was even more real to him than me."

"Oh," Sarah finally managed to say.

"Your grandfather felt that every minute of life had to be devoted to reminding the world. Except instead of bothering the world, he bothered your grandmother and me. When you were born, I promised myself that I wouldn't let him warp your life the way he warped mine."

"But your life isn't—" Sarah cut herself off.

Her mother chuckled bitterly. "It isn't warped? Sarah, compare your life to mine; you've always had more choices than I did. In my day, there was still so much women couldn't do, or wouldn't be allowed to do. Things were good for a while, but then when the Supreme Court overturned Roe v. Wade, it was like the clock turned backwards for all women. And for a Jewish woman, the only daughter of a survivor—" She stopped.

"Yes, Mother?"

"Let's just say that your father was not the first man I wanted to marry. But your grandfather, well . . . " She trailed off.

There was nothing Sarah could think of in reply, and her mother gave her a sad smile. "Now maybe, you understand," she whispered.

"And maybe you do too," Sarah whispered back, a question and a statement at the same time.

Mother and daughter regarded each other for a moment, and then Sarah spoke. "I'm going upstairs to see Grampa, Mother. It's my last chance."

Her mother sighed. "Go. I've already made my peace with him. We'll talk more later, after—when there isn't so little time."

Grampa looked so weak lying in the hospital bed that U.S. Hospice had pro-

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vided. Where was the strong man of Sarah's childhood, the Grampa who had carried her on his shoulders at the playground, who had comforted her on her first frightening day of school, who had attended her high school graduation just five years ago? This old, frail shell of a man, lying in bed with blankets around his thin body and snoring weakly—Sarah couldn't reconcile him with her memories of her grandfather.

Then, tattooed upon his left arm, she saw the number: 110290. It had always been there. She remembered that first time she had asked Grampa about it. She'd been six years old. He had taken her to the playground near the house, on a hot summer day. Grampa took off the raincoat he always wore, sat on a bench with other old people, and let Sarah run off and play while he "snoozed and schmoozed," as he liked to call it. She never understood how he could sleep with all the noise from all the children playing, but Grampa seemed able to sleep anywhere. It might have scared her, but he always woke up when she called him.

When she returned, she was shocked to see that Grampa had rolled up his sleeves because of the heat. Grampa never rolled up his sleeves.

"Grampa," Sarah had asked, "what's that?" Her little fingers reached out to touch the number.

He woke instantly. "What is what?"

"That number. What is it?"

Grampa saw what she was looking at and quickly rolled down his sleeve. "Better you shouldn't ask," he said, and glared at her. Then his face softened. "*Saraleh*, how old are you again?"

She laughed. "Six, silly!"

"Six." He looked into the distance for a moment. "I had a sister who was six, once. She never got to be seven."

Grampa had had a sister? Sarah had never heard of this before. "What was her name?"

"Sarah. You were named for her." He looked at his left arm, and rolled the sleeve back up, displaying the tattoo. "I was sixteen; that was when I got the number. Sarah, forget what I said before. It is better that you ask. You must ask. And remember."

He had told her of the horrors of the camp. Of how his own grandfather had disappeared one night. Of how he, his parents, and his little sister were taken away in cattle cars from their home to a place called Auschwitz, where they were separated, and how he never saw them again. Of how he had very little to eat, all of it bad. Of how he had to endure the beatings of the guards. Of how he got sick with typhus and thought that he would be sent to the gas chambers and turned into smoke and ash. Of how they marched him to Buchenwald, and how he almost collapsed and died along the way. Of how he was barely able to move when the Americans came to liberate them, and how two righteous Gentiles whose names had sounded Jewish, Sergeant Rosenthal and Corporal Glaub, had attended to him and nursed him back to health.

His stories had seemed so incongruous in the bright, sunny playground filled with the laughter of little children, and at first Sarah thought he was making them up. But as the stories continued and got more horrible, Sarah became mesmerized. When he finished, Grampa had tears in his eyes. She hugged him, and he trembled just like Sarah did when she woke up from a nightmare.

That night, so many years ago, the rain had pounded on Sarah's bedroom window like gunshots. It was a hot, humid night, and as Sarah drifted off to sleep she thought of all her grandfather had told her. She dreamed of being stuffed into a gas chamber, the stink and sweat of human flesh pressing on her from all sides, Nazi stormtroopers shooting people outside, human flesh burning, going up in sweet-smelling smoke—

And she awoke, screaming and crying. Her mother had come in and held her for a long time. When she found out

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about Sarah's dreams, she promised Sarah that she would never have such dreams again. From that day on, Grampa never took Sarah to the playground alone. And the nightmares had faded away and disappeared, except for the memory of the number on Grampa's arm: 110290.

Sarah shook her head, clearing away the memories of that long ago night, and looked at the bed. The frail old man wrapped in blankets had that same number, 110290, tattooed on his arm. There was no question in Sarah's mind now, that this man was her grandfather, lying in his bed.

And dying.

I shouldn't disturb him, Sarah thought, and had turned around to leave the room when she heard his voice. "Who's there?" Even when he was dying, he woke to the sound of her.

She turned back; her grandfather's eyes were open. "It's Sarah, Grampa."

He smiled. "*Saraleh*, it's good to see you." He struggled to sit up in bed, and coughed. "Here, come sit next to me, on the bed. We'll have one last chance to snooze and schmooze before I go."

"Grampa! Don't talk like that." She moved his blankets over and sat down.

"Sarah, Sarah. Years ago, it would have been tempting the evil eye to say such things, but now . . . now I am dying. And I am looking forward to peace. I have not had a peaceful life, *mameleh*."

"I know."

"So *nu*. Tell me, how are things? What are you doing with yourself?"

Sarah shifted around. "Well, I'm living in New York City now, you know. I'm working for a web publisher. Editing."

"And are you enjoying it?"

"I suppose, although what I'd really like to do is write."

"Eh. And are you seeing anyone? I want great-grandchildren, you know."

He laughed, and Sarah joined in. "You remember Tom, don't you? We're living—I mean, he's now at NYU, in law school."

Grampa fixed Sarah with a long gaze. "So, you're living together?"

Sarah blushed. "Yes. Um, I tried to keep it a secret. I'm sorry."

"What is there to be sorry about?"

"Well, it's just . . . " Sarah trailed off.

"It's OK, *Saraleh*. I understand your generation. It is not that much different from mine."

"But you don't approve of Tom, do you?"

Grampa sighed. "Tom's a good boy, a fine young man. I would have preferred if you had met someone Jewish, but I can't fault you for your choice. He will make a good husband."

Sarah thought for a moment. "Grampa, can I ask you something?"

"Anything, *mameleh*. But you'd better hurry." They both smiled at that. Sarah blinked hard, to stop the tears.

"Why is it so important to you that I marry someone Jewish? It's not like you were ever religious or observant."

Grampa closed his eyes and took a deep breath. "You ask such a difficult question, like the simple child's question about the Passover *seder*. It's true, I never was observant, not before the camp, or after. But, Sarah, because of where I was—Auschwitz—your children *have* to remember, they *have* to know what they are and understand where they came from. I need them to be Jewish, and not just because you are. They have to *know* that they are Jewish."

"But why?"

He sighed. "Because if they do not realize who they are, they will be the first to go to the gas chambers the next time there is a Holocaust."

Sarah was shocked. "Grampa, you can't seriously believe that it could happen again. The Holocaust is a distant memory from the last century. Even if it did happen—"

"If it happens . . . when it happens, God forbid, again, the first Jews to die will be the ones who don't realize they

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are Jewish. The German Jews saw what Hitler was doing. They were Germans, they said, not Jews. What Hitler is doing doesn't apply to us. They never believed it would . . . until it was too late."

"But it couldn't happen again. Could it?"

Grampa was silent for a moment. "Sarah, your generation grew up in a world that felt much safer than mine. We made it that way. Maybe it really wasn't so safe, maybe we weren't so bright, but your parents and I certainly tried to protect you from the world outside. Maybe we succeeded too well.

"It is because you feel so safe and because the Holocaust is so distant, that your generation is in danger. People are forgetting. The Holocaust Museum in Washington lost its funding and is gone now, after only thirty years, because no one thought it was important anymore. Auschwitz—Auschwitz is now a side attraction for people going to the VR mall across the way." Straining, he bent his head over and spit on the floor. "There are even people who claim the Holocaust never happened in the first place, people who are being taken far too seriously."

"I know what you mean. Just outside—" Sarah bit her lip.

But it was too late. "What? What happened outside?"

Sarah shrugged. "A reporter. He—he accused us of making it all up."

Grampa frowned, his voice bitter. "Always," he said. "Always the big lie. Well, they wouldn't let me live in peace. Why should I expect then to let me die in peace?"

"It was only one, Grampa," Sarah said, dismissively. "The other reporters are—I mean, they know it's for real."

"Even one person denying the truth is one person too many." He sighed. "The deniers are everywhere, Sarah. They started when I was just out of the camps, telling me that the horrible things I had seen with my own eyes never existed. Telling me I was crazy. But there were always enough of us around, to educate, to lecture, to write, to bear witness for the world. But now—"

He coughed, loud, long, and hard. Sarah stood up. "Grampa, you must rest. You're letting yourself get all worked up. I'll go get you some water."

He shook his head and waved for her to sit back down again. "Please, Sarah, wait. I don't have much time, and this is far too important."

She sat down again. "Yes, Grampa, what is it?"

"Sarah, you must promise me. After I am gone, there will be no one to bear witness. I am the last of the survivors. *You* must bear witness for me—for all of us, the six million who died and those who survived to tell the world." He took her left hand in a grip that was surprisingly strong.

Now the tears welled up in her eyes, past her strength to hold them back. She began to weep. "Yes, Grampa, I will."

Her tears blurred her sight, and Sarah wiped them away. As her vision cleared, Sarah noticed Grampa staring directly into her eyes.

"Sarah, listen carefully. I want you to open that drawer over there." With his right hand, Grampa pointed to the top drawer of the bureau. Sarah let go of his left hand, dutifully walked over to the bureau, and pulled the drawer open. It contained only one item, a small shiny metal box with the logo MEMVOX printed across the side. She pulled it out and turned it around, studying it.

"My God, Grampa," she said. "Is this what I think it is?"

He nodded. "A memory recorder. The chip is inside."

Sarah hesitated before asking her next question. She feared she already knew the answer. "Grampa . . . what's on it?"

He coughed. "Me. When I am gone, I want you to play it."

Sarah now understood what Grampa had meant about her bearing witness. She shook her head. "I can't do this, Grampa."

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"You will do the right thing, I am sure of it. Sarah, you must. You're young, you're strong, you can handle it. When you play that chip, *you* will be the last survivor." He coughed. "*Zachor*. Remember. Bear witness, from generation to generation." He turned away from her, began to recite the Jewish affirmation in the existence of God, "*Sh'ma Yisroel* . . . " His voice trailed off. His breath faded. Then it ceased entirely.

Sarah wiped the tears from her eyes. She stood up, then covered her grandfather's face with the blanket. She finished reciting the Sh'ma for her grandfather in English; she hadn't realized that she remembered: *Hear, O Israel, the Lord is God, the Lord is One*. She stood up, turned off the light, and left, closing the door silently behind her.

That night, Sarah sat alone in the bedroom of the two-room Manhattan apartment she shared with Tom. She had asked Tom for some privacy, and he had readily agreed; so he was in their living room, watching TV or logged onto the Internet, Sarah wasn't sure. Tom had assumed that the stress of the quick late afternoon funeral and burial was what had prompted Sarah to ask for some time to herself, and she had chosen not to correct him. She was glad that Jewish tradition held that a funeral and burial should take place as soon as possible after death; she had a lot to think about, and didn't want to have to worry about seeing her mother again so soon after Grampa's death.

On the small night table in front of her sat the memory recorder and the chip. She picked up the chip and turned it over and over in her hands. Grampa had labeled it in black ink with his name and date of birth. Sarah had written in today's date at the bottom of the label, in blue ink, but that was all she had done so far. Tom had given her the privacy she requested over half an hour ago, and Sarah still wasn't sure what to do.

A wastebasket sat next to their second-hand full-size bed. Sarah could just drop the chip into it, and never think of it again. Or she could take it to a recycling center, and get some small amount of money for it. As for the memory recorder, although used, it was valuable, and could easily pay the rent for the next few months.

But that would almost be like desecrating her grandfather's grave. Grampa had given her the recorder and the chip for a reason. He wanted her to play it, to share those experiences with her. She thought about those experiences, the stories he had told her about the Holocaust when she was six years old; and she realized that she would never want to live through it herself, even vicariously through someone else's memories. She held the chip above the wastebasket, ready to let it fall—

—And then she remembered the reporter from this morning.

She had to fulfill her promise; her grandfather had depended on it. Quickly, so she would not be tempted into changing her mind again, she inserted the chip into the recorder, attached the wires to her head, and hit PLAY.

An hour later, when the chip had finished playing, she slowly removed the wires. She shuddered and began to cry, but softly, so as not to alert Tom. She removed the chip from the recorder and stored it safely away. The memories from her grandfather's Holocaust experiences precipitated in her a decision, a choice; she just hoped that Tom would understand. She knew that she would have to find someone knowledgeable about computers and recorders, someone sympathetic to her position who could hack the Internet and force Grampa's memory records to be played by anyone plugging in, at least for a short while. Sarah would come forward and take responsibility, once she was assured that no one would ever take the revisionists seriously again. But . . . if she went forward with this plan, to bear wit-

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ness for her grandfather, there was one other step she needed to take first.

Sarah walked into the tiny store, a remnant of the old Times Square, struggling against the gentrification of the past thirty years. Most places of this sort had moved to the outer boroughs of Queens and Brooklyn, but this one was still here. The sign above the glass bore the one word ADULT, in large black letters, and hanging the window Sarah could see signs promising things like fake ID chips and real tobacco cigarettes.

She strode in purposefully, ignored the grime of the floor and shelves, and walked through to the room in the back, where the guy she was looking for worked. The room was small, empty at the moment except for the artist, who was reading a newstape as she entered. His appearance repulsed her, as he had rings through his nose, ears, and eyebrows, and he also sported tattoos on his arms and face. She would never see a person like this socially, but she was here for something else. The guy looked up at her inquisitively as she approached.

"Hello," she said. "I'd—I'd like to get a tattoo. Can you tattoo on a number?"

"Sure," he said, putting down the newstape. "I can do anything."

"Good." Sarah sat on the long chair meant for his clients and rolled up the sleeve of her right arm. "I want you to tattoo the number 110290 right here."

The man looked askance at her. "Like a Holocaust victim?"

Sarah nodded, pleased that the guy recognized what she wanted. She would still go through with her plan, but for the first time since her grandfather died, she thought that perhaps there was still hope for the world to remember its history after all. "Yes," she said. "Exactly like that."□

An integrated field of dream study would be a new fusion of disciplines, in which scientists appreciate open-eyed straining to see everything that there is to see, and explorers appreciate scientific striving for clarity and sureness. We would manifest in a new way this fundamental attitude of science: Look to nature, not to received wisdom or other preconception, to learn how nature works. Look through the eyes both creative and discriminating, and use imagination in your seeing. In fact, use every way of looking that you can.

— Dennis Schmidt
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CHECK FLIGHT

Michael F. Flynn

Illustration by Laurie Harden

The best tests aren't always in the book—and they're never easy.

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The first thing Jacinta Rosario saw as she climbed the companionway ladder onto the flight deck of RS 178 *Bobbi Trout* was Chase Coughlin slacking and grinning in the supercargo seat.

"The circle is now complete," Chase said, *basso profundo*. "When last we met, I was the master and you, the student. Now, *you* are the master."

Jacinta did not understand why the line was supposed to be so funny, but that might have been her own nervousness. The companionway was in the center of a circular deck, "The Donut." Looking around, she saw the copilot and flight engineer already busy at their boards at the ten o'clock and two o'clock positions. The flight captain's seat at "high noon" stood empty. Jacinta stared at the seat for a moment, took a deep breath, then climbed the last few rungs onto the deck, dogging the hatch behind her.

"Captain on deck!" Chase called out sharply, causing Jacinta to jump and the other two crew members to glance across the room. Jacinta leaned toward Chase.

"I'm only 'master' for one flight," she said. "After this, I revert to pumpkin."

Chase's grin turned serious. "But you *are* the master. Says so on the articles. Don't you dare forget it, even for a moment. I downchecked a candidate last year because he kept looking over to me for confirmation. For the duration of this flight, Ms. Rosario, 'You the Man.' Me. . . ." He kicked back. "I'm just along for the ride."

"Yes, sir."

"Don't 'yessir' me. I'm not here. Get on with it, *captain*."

Jacinta swallowed, nodded, then walked around the donut to the captain's position. She turned the padded chair and ran her hand over the cool leather. How long had she dreamed of sitting here? As long as she could remember. She had spent twelve months as Captain Honnycott's midshipman, executing lifts, rendezvous, dockings, and landings under his meticulous and often sarcastic supervision. Her flight schedule had been grueling but it had also been exceedingly thorough.

Today the training wheels came off.

She lowered herself into the soft, contoured seat. Live fire exercise. Legally in command. Responsible for the cargo. But passing would entitle her only to a third stripe and a left-seat billet. Only time and experience would entitle her to the center seat.

She turned to the copilot. "Do you have the manifest, Ms. Meredith?"

Total Meredith handed her the Gyricon thinscreen, contriving to touch hands as she did. "All stowed and inspected, Captain," she said with a smile.

Jacinta's answering smile was fleeting and nervous. She remembered how kick Chase had been on her first flight—"laid back," as her gramma used to say. But how could anyone relax when she was responsible for—she scanned the list—three multi-million dollar satellites, the lives of twenty otters headed for Goddard City, and supplies for the mysterious Project Lariat? She thumbed off on the list and handed it back.

"Relax," Total said. "Just another sim. You made it through the written and the orals. This part should be easy." Then, in a softer voice, she added, "You're looking good, 'Cinta."

Totally Awesome Meredith was looking good, too. She had been a pinned cadet during Jacinta's nooboo year at the Academy. Hard-muscled and lean as a whippet, with her short-cropped hair aggressively spiked, she moved with the tightly leashed grace that only years of practice in the martial arts could bestow. The huntresses, the sisterhood to which Total belonged, emphasized physical culture in the way Jacinta's own silver apples emphasized communication and body language. Both paths led to mastery of the self; both paths had kept them safe from the predatory streets until they had gotten command

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of their own compass.

After the accident in the Neutral Buoyancy Tank when Jacinta had nearly drowned, Total had breathed life back into her. Yungduk Morrisey had lifted her from the depths and Total had lifted her from the darkness. A two-fold debt, never repaid; and Jacinta suspected the payment each of her two debtors sought would preclude the other.

"Nice to see you again," she said in the Voice of Comradeship, carefully keeping intimacy from her tones. Jacinta had always admired the huntress' poise and confidence; the way she had found and maintained her own center; her willingness to take a risk and the confidence that she could meet it; her comfort in her own body. But Total wanted more than admiration from Jacinta.

Jacinta turned her seat to face front—outboard, actually—and activated the preflight checklist on her chair screen. "Flying commercial now?" she asked in the same abstract, friendly-but-distanced tones. Unlike Chase and flight engineer Yoshimura, who wore Aurora purple, and Jacinta, who still wore academy blue, Total was sheathed in the midnight black coveralls of Air Force Space Operations, with the trim, the three bands at her cuffs, and the spaceship-and-planet AFSO logo done up in silver. She flew with the Emergency Response Team, the AFSO-managed civilian volunteer pool that stood ready for on-orbit rescue.

"No, ma'am," the other sister answered. "Just logging some proficiency hours. The flock doesn't fly every day, so ERT ready crews spend most of their time compressing butts."

Jacinta turned to the flight engineer on her right with not a little relief. "Hi, Yoshi. Ship check out?" Midshipmen stuck with their captain-instructor like moss to a bureaucrat, but crew assignments were "mix 'n match," so she and Kenji Yoshimura had crossed orbits a few times during the past year.

Yoshi handed her his own thinscreen. "There was a malf on the number three standby computer, but I have addressed that."

Chase laughed and spoke for the first time since Jacinta had taken the command seat. "He whacked it with his shoe."

Jacinta raised an eyebrow to the engineer, who shrugged. "It's working now," he pointed out.

"Anything else?"

"We replaced the number three diverter valve and an airflow recirculation control relay that wouldn't calibrate."

Jacinta nodded. "Thank you, Yoshi." She scanned the rest of the report, thumbed it, and returned it to the F/E.

"You read that engineer's report damn fast," Chase said.

Jacinta turned her seat to face the check-pilot. Was he hinting that she had done something wrong? Or was he complimenting her on her efficiency? "I have an F/E ticket," she said. "I sat for the exam a few months ago—under Yoshi, as a matter of fact."

Chase showed surprise. "I thought piloting was the itch you wanted to scratch. What's the flight engineer certificate for, a fallback position in case you wash out?"

And what did that tone of voice mean? Disapproval? "I don't wash out," she answered him. "But a silver apple *always* acquires more than one skill. It makes me more marketable, adds reliability to normal flight crews through skill redundancy, and—if they ever mount a crew with a need to double up on billets, I've got a better chance of making the cut." She spun back forward, wondering if she had revealed too much of herself. She knew it made her seem standoffish, but she did not like talking about her inner desires.

"Doubling up on billets," Total murmured. "Now, what flight could that possibly be?"

"Just thinking ahead, is all," Jacinta answered; then, in normal tones, "Departure window?"

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"Opens in twenty," Total reported. "Closes in fifty."

"Weather report?"

"Terrestrial weather . . . Low pressure center over the Carolinas. There may be some turbulence on the ascent path. Solar weather . . . Seventy-percent chance of flare with charged-particle sleet."

Jacinta was not too concerned with the flare warning. Her flight plan was below the Van Allens, but the folks on Upabove Station and the other twenty-fours might have to button up. Most ships and habitats were equipped with hobartium belts—loops of superconductor—whose magfields would divert the sleet, but ionizing radiation could still be a problem.

She worked her way methodically down the checklist, activating systems, checking status. Cabin pressure. HVAC. Air and water regen. Radars. Outside view pickups. Fuel load. Radio frequencies for Skyport Allentown and Recife STC. At some point, she knew, it would all become second nature; but she had *never* seen Captain Honnycott make a lift without using the checklist. Each model ship was a little different, he had explained. Planks, Black Horses, Rotrons, Lock-Mar cruisers . . . Not to mention the OTVs and LTVs and Luna lighters. Even the different Planks. *Chkalov* class handled differently from *Quimby* class, for example. Preflight, Choo-choo had told her, was the most important part of the trip because a screwup in preflight could mean an unrecoverable malf later on. Jacinta thumbed each item as it was confirmed. Chase said nothing the whole while, but she was acutely aware of his eyes on her while she worked.

The background whine of the LOX and LH2 compressors, which had been barely audible through the plated aerogel hull, ceased, and a few moments later Yoshi announced that the ground crew had cleared the pad.

"Fuel pump status?" Jacinta asked.

Yoshi flipped some switches. "Function verified."

"Set active standby mode."

"Active standby mode, aye."

"All the otters buckled up?" The engineer reported everything nominal on the passenger deck. Jacinta took a deep breath and called on her inner strength. Then she opened the link to Space Traffic Control. "Allentown Tower, this is Aurora 238 requesting clearance to lift."

"Acknowledged. Climb bucket is clear of air traffic. You are number two after Kelly 46."

"Roger." The climb bucket was a cylinder of restricted airspace sixty thousand feet tall and five miles wide to accommodate the circular "noise footprint" of vertical lift and landing. Spaceplanes—which employed horizontal flight—used a much broader noise field west of the spaceport. Yoshi hit the klaxon once and Total got on the horn to alert the "cargo." Every otter knew what one blast meant, but the regs said you had to tell them anyway.

Shortly, the fuselage shuddered and a faint boom sounded without. That was Kelly four-six lifting for the SPS-4 construction site in geosynch. She tried to follow Kelly's flight path in her mind, counting off the seconds. Climb. Climb. Begin gravity turn. Alignment check. Torch and . . . Depart. Bucket clear.

No squawk from the tower. Jacinta tried not to bite her lip. Was something wrong? She clenched her hand over the abort button. The computer handled the lift once they'd programmed it, but the pilot had to be ready to abort if anything malfed on the upstroke.

Then the radio spoke. "Aurora two-three-eight, Allentown STC. Cleared for lift. Climb unrestricted on flight plan as filed. Passing Flight Level Six Zero Zero, contact North American Space Control Center. Have a good flight. . . . And good luck, Rosario."

Jacinta grunted. There were a lot of otters, dogs, and bunnies in the spaceflight community, but it was still small enough that everyone knew what was

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going down. Still, it was nice to know there were others pulling for you. "Acknowledged," she said. "Climb unrestricted per flight plan. Contact North American SCC at FL Six Zero Zero. And I will have a good flight, but only since you insist." She cut off just as the laughter erupted in the tower. "But luck," she added, turning to Total, "has nothing to do with it . . . Yoshi, activate fuel pumps." The faint vibration came to her through the seat. "Ignition." She threw the gang switch for all five engines. The ship bucked and trembled as the torch lit.

"We have function," Yoshi announced. "Board is green for go."

"Full throttle!" Yoshi hit the klaxon three times. Jacinta watched the dynes climb on the status board, felt the shaking build in the frame. Then, before her throat could close up on her, she announced, "Up ship!" and RS 178 *Bobbi Trout*, acting captain Jacinta Rosario her master and commander, broke the sky.

It was a heavy lift and the "Flying Fish" hit LEO as dry as the alkali flats near Glenn Academy. Jacinta had noted the mass on the manifest, but was surprised to discover that she could feel the difference in the way the ship handled during the lift. Well, this might be her first lift in command, but she had taken up a half-dozen ships under Choo-choo's tutelage. After a while, you started to notice little things.

Yoshi confirmed the fuel usage—enough to close with Goddard Free Port—but that didn't bother her. There was a gas station in Goddard's sub-orbs. The habitat fell in orbit twenty-eight-slash-thirty, while an Allentown lift put the *Trout* into orbit forty-slash-thirty; so there'd be a planar change, but a relatively minor one. She told Total to verify their position with NASCC and tweak the burn schedule for the close approach accordingly. Then she double-checked the calculations herself, not because she didn't trust Total's skill, but because a dry-tank approach left little room for error and an independent verification was a reasonable precaution.

Once they were in the slot, Jacinta and her crew relaxed. Closing with Goddard City was just a matter of waiting until chaser and chase fell to the same point. When she turned her seat around, Jacinta saw Coughlin making notes on a Gyricon thinscreen. The supercargo seat at the six o'clock position had a full set of readouts, though no controls, so her examiner knew every move she made. She thought about asking how she was doing, but didn't want to get downchecked. Besides, a flight captain *knew* how she was doing (which was "damn good," in her case). Everything was nominal—fuel usage, longitude of ascending node, argument of perigee, time of perigee passage, velocity relative to the chase, distance to the chase—and she didn't think you could go too far wrong bringing the flight in on schedule.

Though, speaking of distance to the chase . . .

She studied the check-captain covertly. Coughlin shaved the sides of his head and kept the center short and spiked, much like Total. Late thirties—but with his sidewalls shaved like that, you couldn't tell if the temples had grayed. Which was maybe the whole idea. He wasn't *old* exactly, though his career spanned the divide between the early flight test days and the routine commercial era. Back in Nine he had helped Ned DuBois take the old *Glenn Curtiss* to the moon, which had led to a minor fad for "moon-storming" ships that were about to be decommissioned.

Chase noticed her and sent a sly grin and a cocked eyebrow in return. Jacinta turned hastily away. Chase was narrow-faced and pale and his eyes were set a little too close together for her taste, but there was no doubt he was an attractive man. She remembered how his arms had felt, holding her tight after those terrifying minutes inside the malfunction-

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ing nozzle of the *Hubert Latham*. He could have taken liberties then and pleaded misunderstanding after; but he hadn't, and that counted for something.

They dropped off the otters at Goddard Free Port and picked up a work crew that was rotating Earthside. They also loaded a sizable consignment of Rodriguez-Baker nanofibers, which were used Earthside to make fuel canisters for electric cars. Nanofibers were related to buckyballs and absorbed up to 65% of their own weight in hydrogen, even at room temperature, a storage method that made fuel cells not only economical but also acceptable to a public nervous about "exploding cars."

Before leaving Goddard, they topped off. The LOX and LH2 tanks at Goddard's tank farm were painted bright white and orange, respectively. Bold black lettering on one tank announced: LUNAGAS: *Finest LOX moonrock can yield*. Jacinta snorted, as she had the first time she had seen it. "Oxy is oxy," she said.

"Sure," said Chase. "It's the impurities that can screw you. Trace elements and contaminants can gum up your rocket engines with weird byproducts. Wheezer Hottlemeyer topped off with contaminated LOX one time and wound up with yoorz in the fuel injectors."

Jancinta turned in her seat and frowned. "What's 'yoorz'?"

"Single malt scotch. What's yours?"

Jacinta took off her gimme cap. "A moment of silence, please, on the flight deck."

Now it was Chase's turn to frown. "What for?"

"That joke was dead on arrival. We ought to show some respect."

Chase barked laughter and, for a moment, the two of them locked gazes and something passed between them. What that something was, Jacinta could not guess, and she turned away from her examiner before she was tempted to find out.

"All hatches sealed," announced Yoshi as he returned to the flight deck. "Cargo is stowed and battened."

"C of M?"

"Nominal."

"Good." Jacinta pulled her harness closed. "Mild boost. Compressed gas. Retrograde. Prepare to disengage."

"Orbiter, six o'clock, low," Total reported. "Closing and rising."

"Trajectory?"

Total studied her boards for a moment. "Closest approach, two point three kilometers. Looks like a docking approach."

"Heavy traffic," said Yoshi, shaking his head.

"I feel your pain," Jacinta told him. "Put the comm laser on that ship, Total. Let's say hello."

Total set target and frequency, then thumbed her mike. "*Hóigh*, approaching ship, this is RS 178, *Bobbi Trout* out of Port Allentown, bound for 10K-zero-zero with a load of satellites. Where away?" Total had cited the first three parameters of their destination orbit: argument of perigee, eccentricity, and inclination.

The responding hail followed close on. "*Bobbi Trout*, this is RS 204, *Carlo Piazza*, out of Prague Skyport, bound for the LEO circuit with R&M and life support supplies for Goddard, Leo Station and Europa; acting captain Yung-duk Morrisey, master and commander."

If ziggy had allowed it, Jacinta would have bolted upright in her seat. Yung-duk? Here? And they had missed each other by minutes! She toggled her own mike, cutting in on Total. "Duck, this is 'Cinta!"

"'Cinta?" The delight in his voice was palpable and not, Jacinta suspected, only to those trained in Voices and Postures. "Coming or going?" he asked.

"Going. We just topped off at the tank farm."

Pause. Then, "That's too bad. Ships passing in the night. Maybe next time we can dock together . . ."

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Jacinta flushed. In otter slang, "docking" could mean something else, not involving ship and port. She flipped her comm to *private*. "Duck," she whispered, "you were on the flight deck PA."

"What, you afraid your crew will learn I'm in love with the smartest and most beautiful ensign that ever won her pin? I don't care who knows . . .

Oh, beautiful for spacious eyes, (he sang)

For raven locks of hair.

For—"

"Duck!" The Voice of Total Embarrassment was not one of the canonical Voices the sisterhood taught, but she used it nonetheless. "If the next line has any reference to 'mountains,' I'll never speak to you again."

How could you hear a grin over a microwave laser comm link? Yet she did. "What say we meet at Miguel's in Tehachapi after we get our stripes," Yungduk suggested. "Kenn Rowley is going up tomorrow. The three of us can celebrate together."

"Set it up and let me know by voicemail. But if Kenn can't match orbits, that's not a deal-killer." That was as close as she dared say out loud that she didn't mind going out alone with him.

After they had signed off, Jacinta became very busy at her board. "We have to set up for the planar shift," she said after a moment. "Our birds have to be dropped in equatorial orbits." When she glanced up, Total's gaze was unreadable.

"Yungduk Morrisey?" she said, making it a question and perhaps an indictment.

Jacinta wouldn't quite look at her. "We began seeing each other during the recession, when the Academy shut down. We helped each other maintain proficiency." Then, almost in protest. "He's really a bone charlie. The sisters approve of him."

Total turned back to her own board. "Confirm apogee at 300 kilometers," she said, suddenly all business. "Hohmann transfer to destination altitude, burn at ascending node. Calculated delta-V to enter Hohmann transfer is . . . " She consulted the ship's orbital deeby. " . . . 1200 meters per second. Total delta-V is 2200 meeps. Estimated transfer time, one hour, twenty-three minutes."

Jacinta was just as happy to drop the subject. "We'll gyro as we ascend," she announced, "and combine the horizontal burn with the apogee kick. A planar change of twenty-eight degrees thirty needs fifty-two percent of our velocity, so we might as well do it when we slow down at the top of the loop." She didn't know why she was babbling like this. To show Chase she knew her stuff? But nervous chatter might actually count against her. The transfer was already programmed into the flight plan and neither the copilot's report on orbital position nor the engineer's report on fuel usage and equipment function had given her a reason to modify the preset plan. She took a deep breath. How many candidates had washed out because they had tried too hard?

"So you've got a boyfriend now," Chase Coughlin said, after the orbital change had been executed and the crew was once more standing down. Space flight was like that. Meticulous calculations, split-second timing, then nothing but waiting. "I thought you didn't go in for that sort of thing."

Jacinta kept her back to her examiner. Was he *trying* to rattle her? "What do you mean, Captain?"

"Don't call me 'captain.' This flight deck only has room for one of those. I'm 'Mr. Coughlin' for formal purposes; 'Chase' at all other times. And what I meant was, I thought your sisterhood was into celibacy or something."

"Chastity," she told him. "It's not the same thing." She didn't ask him what the 'or something' was and she barely glanced at Total when she thought about what other somethings there were.

"So," said Coughlin, "you're chaste

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while I'm Chase." He seemed to think that was enormously funny and Jacinta said nothing to correct him. The older generation as a rule found chastity and self-respect amusing. The Boomers were even worse than Chase's generation—they seemed to regard sex as a sort of sacrament and acted as if being "uptight" and "Victorian" was worse than leaving unwanted babies with young, abandoned mothers.

"Too damn bad," Chase said, and this time Jacinta did turn to face him.

"What is?" she said in the Voice of Contention.

"You having a boyfriend. It means you're off the market."

Market . . . How like Exers to compare something so deeply personal to a cash transaction. "So are you," she pointed out. "You're married."

"That's the theory, anyway," he said with a grin.

But the falsity in his voice startled Jacinta into momentary silence. It was all an *act?* The Punk Pilot of the Spaceways was straight-edge? She tested him by asking in flip tones, "What, your wife doesn't understand you?"

His grin widened. "Heck, I don't understand me." And the deft way he had dodged the question was all the confirmation Jacinta needed. This guy was *married.* In the true meaning of the word, he was as chaste as she was.

And yet . . .

There was something in his eyes when he looked at her.

They had already launched two of the satellites and Yoshi had gone aft to load the third one in the slinger when the call came in. Total suddenly stiffened and put a hand to her ear-clip. She listened a moment, then said, "Captain, you better listen to this," and flipped the switch for the speakers.

" . . . say again, this is OTV *Harry Stine* at SPS-5. There has been an accident during docking. Both the ship and the habitat have been breached and are losing pressure. Three confirmed dead and one missing, all of them powersat personnel. Mayday, mayday. All ships and stations. This is OTV —"

"*Harry Stine,*" another voice broke in, "this is GEO STC at Upabove Station. What is your situation?" Jacinta, still listening, bent over her boards and began feeding queries to the navigational deeby.

"Upabove, this is Lieutenant-Captain Adrienne Coster, piloting OTV *Harry Stine.* Our attitude jet malfed during docking and we corkscrewed the lock, hard. The whole structure's twisted out of alignment. Our nose is breached and the first interlock is misaligned. Won't seal properly. Command module is losing pressure. Powersat—they tell me their receiving module is open to vacuum. Three dead, one missing—but the missing otter wasn't suited up, so . . . Adjacent modules are also leaking. Wait one . . . "

Jacinta could hear the tightly controlled panic in Adrienne's voice; yet she worked through the emergency as methodically as if she did it every day. *You go, girl.*

"*Harry Stine,* Upabove STC. Be advised. GEO Shuttle *Graham* is on its way."

Silence from Adrienne. Then: "Acknowledged. I am informed that SPS-5 is currently unsustainable for life support. Construction gang numbers twenty-four. Correction, now twenty. Five workers report being trapped in pressure without access to suits. Two others were suited and outside at impact and are currently on suit air and power. Remainder of construction gang has taken refuge in two intact modules. They are suiting up, but have nowhere to go. Be advised: Time is not our friend."

And that, thought Jacinta Rosario, would go down in history as the greatest understatement of the 21st century. She studied the readouts her search engine had collated. Scratch *Carlo Piazza.* Yungduk was still refueling. *Henri*

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Farman had cast loose from Europa for an Earthside drop just before the mayday and could not abort to orbit. *Lotus Blossom* had just lifted for Tien Tao, but would hit LEO nearly as dry as Jacinta had and would also need to refuel. *Princess Shakovskaya* was moored and fully fueled at Tsiolkovsigrad, but would not have a launch window to SPS-5 for another forty-five minutes and their minimum-time trajectory required a fuel-slurping planar change. What else was up? What else? The OTVs . . . But they were basically tugboats and couldn't carry any more people than the *Graham*.

"Attention . . . " It was a third voice. "This is Jason Ulundi, Emergency Response Team, Nairobi Spaceport. The flock is flying. RS 217 *Claude Grahame-White* departed Nairobi at ten-oh-eight. RS 76 *Santos-Dumont III* departs Recife at ten-thirteen."

"Acknowledged," said Adrienne Coster. And Jacinta could have recognized *that* voice without any training at all. The voice of despair concealed. She cut off the speaker and turned to Total.

"Lieutenant Meredith, lay in a course for Solar Power Satellite Number Five. Minimum orbital transfer time."

"SPS-5, aye." Total leaned over her board and began searching for trajectories in the deeby. Jacinta toggled her mike and said, "Yoshi, secure all equipment and return to the flight deck immediately. Wait, who's senior among the cargo."

"Crew chief named Mercado," the engineer's voice said over her headset. "What's going on?"

"Bring him with you. I'll tell you when you get here."

"Ensign Rosario!" It was Chase Coughlin and Jacinta turned her seat to face her examiner. "May I remind you that you have a satellite in your hold worth one-point-two million federal dollars," Coughlin said. "If you fail to insert it into the proper orbit, it becomes one-point-two million dollars worth of electronic lawn ornaments."

"Mister Coughlin . . . " She had not missed his use of "ensign" in addressing her. " . . . there are twenty construction workers and two OTV crewmen up there slowly losing air and power."

"The ERT is on it," Chase said, "and Upabove is sending *Graham*."

Jacinta could not decide if he was serious. It was a test—but what was the right answer? "Total, when's our window?"

"Fastest arrival? Engage transfer ellipse in twelve minutes. Transfer time to rendezvous, three hours, twenty four minutes. Next window in thirty-seven, but that's a slower ellipse and we wouldn't rendez' until . . . ."

Jacinta nodded. Until it didn't matter any more. She had surmised as much from her own quick search of the deeby. But . . . Twelve minutes for a decision that could make or break her career? She faced the examiner again. "What would you do, Mr. Coughlin?"

The older captain seemed to withdraw from her. The six o'clock seat was as far from her as the deck allowed, yet he had somehow become farther still. "Are you asking me for orders?"

"No, Mr. Coughlin," she said in the Voice of Command and was surprised to see him flinch. "*I* am the master of this bucket and *I* will decide our course of action. But a captain uses *all* her resources; and those include the instincts and judgement of Aurora's senior pilot. I'm asking for your advice, not your orders."

"Eleven minutes," said Total. Yoshi climbed up through the companionway with one of the otters. "Brief them, Total," Jacinta said. Then, to Chase: "Well, Mr. Coughlin?"

"Can the ERT handle it?"

"Negative. It's a gesture. They can't reach geosynch in one bump. They'll have to refuel, either at Leo Station or T-grad. *Carlo Piazza* and *Shakhovskaya* will be climbing to GEO before the ERT can top off. Bottom line, no one can get there before the guys in the suits run out

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of air and no one but the *Trout* can get there before the five in the leaking module suffocate."

Chase rubbed a hand over his chin. "Guessing, or did you suss the deebies?"

"What do you think?"

"The *Stine's* service module can hold three people in a pinch," he pointed out.

"If they're real skinny. That's Adrienne, her engineer, and one of the suits. The other guy's SOL. You want to tell him?"

He shook his head. "He's SOL anyway. You can't get there before his suit gives out, and neither can the *Graham*."

"That any reason to give up on the others?" She didn't wait for an answer, but turned to Meredith. What was Chase's problem, anyway? Gone suddenly shy of risk? "Total?"

The copilot shrugged. "It's Adrienne," was all she said.

"You know Coster?" Chase asked.

"She was in the cohort between Total and me at the Academy." Jacinta saw no reason to tell Coughlin that, when she was recovering from her near-drowning in the Neutral Bouyancy Tank, Adrienne had visited her and had prayed over her. It hadn't done any harm that Jacinta could see, and maybe it boosted her Inner Strength just a little bit. "She's charlie for live theater," Jacinta remembered.

Total turned to look at her and her mouth twitched. "Among other things."

"We went down to LA once," Jacinta went on. "To see Ntebele's *Helios* at the Space." She grinned a little as she remembered. "Adrienne is so intense. So focused. I thought she was going to climb up on the stage and start giving directions."

"Flight plan entered," Total said.

Jacinta turned to her engineer. "Yoshi?"

"It's your decision."

"I know that. I want your input. You've looked at the trajectory. Can we do it?"

The engineer pouted and looked at infinity. Then, he checked the indicators. "I can coax what she doesn't want to give."

Jacinta turned to the construction boss. "You heard what's going down, Mercado? Good. This isn't a democracy. You don't get to vote. You get to tell me what you think. When we get there, can your people do anything? Can you rig an airtight passage between the station's intact modules and the ship?"

"Lemme see the manifest. See what sorta equipment you have on board. Maybe we can jury rig a temp lock, jus' last long enough to take some suits inside."

"You'll help, then?"

Mercado snorted. "Maybe I got friends up there."

Jacinta nodded. "Maybe we all do." She checked their orbital position, then flipped the horn. "Atlantic STC, this is RS 178 *Bobbi Trout*. Request permission for orbital transfer in—" She glanced at Total, who held up five fingers. "—in five minutes. Destination, geosynch orbit, SPS-5. Purpose, rescue. Please advise of intersecting flight plans." She nodded to Total and the copilot squealed the flight plan to the STC. "Tell Adrienne we're coming."

"Can't," said Total. "They've abandoned the command module and bunkered up in the service module."

"Checklists, people," Rosario said. "Briskly, please."

They went down the critical items for an orbital transfer against the amended flight plan. Jacinta reminded Yoshi of the solar weather warning. GEO flight rules required activating the hobartium belt when passing outside the van Allens during a storm watch. Another reason, she thought, to get to those otters fast and get them inside a magnetic field.

"One minute," said Total.

"Mr. Yoshimura," Jacinta said, "the long horn." The flight engineer sounded the emergency klaxon—a single extended blast. Total looked her way.

"Aren't you going to wait for clear-

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ance from Atlantic?"

Jacinta shook her head. She tried not to think of Chase Coughlin grading her performance. *Ensign Rosario did willfully neglect her assignment and flight plan and execute an O/T on her own authority and without authorization from STC.* "By the time they make up their minds," she said, "we'll be past the window. Those otters up above can't wait for the second window."

"They'll let you commit yourself," Chase said as the second hand swept toward ignition. "Then they'll second-guess you. What that second guess will be depends on how things turn out."

Jacinta's hand moved toward the abort button . . . but not over it, lest the sudden acceleration bring her hand slapping down on top of it. She didn't turn her head to look at her examiner. "Then we better make damn-all sure it turns out right."

Space was the ultimate proactive environment. What you did *right now* fixed precisely what you would be able to do later on. So: "Think, then Act." But don't take too long thinking or your window would pass. Total had set a minimum transfer time orbit—overboost, rotate on gyros, then a fuel-slurping combination radial and posigrade burn when they crossed geosynch. If they foo'ed that maneuver, Jacinta would have to wait until the transfer ellipse apogee'd way the hell up and fell back to GEO for a second try.

Not that it would matter by then.

So, while she in theory had nearly three-and-a-half hours to kill, Jacinta found herself sweating the minutes as she and Total worked out the angles and the timing for the insertion burn. Total verified their location in the J2000 coordinates through Geosynch STC on Up-above Station while Yoshi pondered fuel usage and center-of-mass and Jacinta worried over the thousand ways in which she could still get them all killed. Once, she glanced over her shoulder at Chase, and wondered if the fatalism he and Honnycott and the other senior pilots shared was nothing more than a shield for the awful oppression of responsibility.

Then there was the small matter of what they would do once they matched orbits with the station. The fate of the two otters caught outside would be decided well before the *Trout* could arrive; and the thirteen in the two airtight modules could hang tight until Mercado's people cut through. Adrienne and her engineer would be cramped in the *Stine's* service module, but at least they'd be in pressure.

So, the critical path was the rescue of the five workers isolated in the third module. No suits and slowly losing air and pressure . . . Total established a link with Wong Li, the SPS-5 construction boss, and Wong and Mercado worked out a strategy. The problem was how to open the misaligned interlock without turning a slow leak into an outgushing of what air was left.

"Simple," Mercado told Jacinta as he displayed the schematics Wong had downloaded. He tapped a finger on the throat between the ruptured receiving dock and the cul de sac where the five were trapped. "We take five empty suits in there, then Tonio—he's our smallest welder—he spot-welds a metal disc across this passage. Cork in the bottle—with the suits welded inside. Then the trapped otters come out, get the suits and put them on."

"If they can," Chase Coughlin said from across the deck. Jacinta and Mercado looked up from their study of the schematics.

"What have we overlooked?" she asked.

"Slow leak," the older man reminded them. Mercado slapped his forehead.

"*Ay yi!* Anoxia . . . Right. They could be unconscious. Okay . . . " He studied the dimensions of the shaft more closely. "Okay. Tonio welds in five suits and two otters. That'll be me and . . . Bird

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Winfrey, I think. I'll ask him. This is strictly a volunteer gig."

"I'll do it," Chase said. "I'm a spare wheel here, anyway."

"You know anything about rigging, *mano?* 'Cause that twisted lock, she might not be so easy to open, now that I think about it." He frowned at the plans again. "Maybe Tonio welds us in from the inside, cause he might have to cut through . . . " He shook his head. "Five suits, two otters plus Tonio and his welding rig. 'S getting very crowded in that little passage. Just me an' Tonio, then."

"And you're not volunteering for anything, Mr. Coughlin," Jacinta said. "You are to take the conn of this ship while Total and I enter the *Stine* and rescue Adrienne and her engineer."

Coughlin's face narrowed in disapproval. "Don't try to be a hero. The captain doesn't go out with the 'away team,'" he said.

"And I wouldn't go," Jacinta answered, "except for two things. One: I've got you taking up space. You wanted to volunteer a moment ago? I'm volunteering you for this."

"And the second thing?"

"Adrienne is a friend of ours."

Chase pursed his lips and nodded. "All right . . . I hope she has talent," Chase said. "I mean as an actress or director."

Jacinta turned her seat around. "Interest," she said. "Not talent."

"Too bad. She'll need another career after this."

His offhand callousness angered her. "We don't know that the accident was pilot error," she snapped. "It sounded like an engine malf to me."

Coughlin shook his head and snatched his cliputer, which had been floating beside his seat. "You still don't get it, Rosario. Responsibility isn't about *fault*. Coster's the captain of the tub. It doesn't matter if she screwed up or the ship malfed. It doesn't matter if she was off-watch and asleep, or even medically incapacitated. Her name is on the articles. *Response*-able. That means she has to *answer* for whatever happens. The Board of Inquiry—and trashing one of the powersats means the mother of all boards will be sitting—might clear her of any wrongdoing; but she'll never get another plum assignment."

"That wouldn't be fair . . . "

"Fair? When did fair come into it? No one will ever see captain Coster's name on the duty list again without thinking about the *Wreck of the SPS-5*—and people would rather not think about bad news. That's why —"

He stopped suddenly and pushed himself back into his seat.

Jacinta finished for him. "That's why you reminded me that I wasn't *obligated* to fly to the rescue."

Chase shrugged. "A ship's captain can get away with a lot of crap, as long as it comes out all right in the end. And if it doesn't, then it doesn't matter if she did everything by the book. STC didn't come back with your authorization because if they'd *ordered* you to SPS-5 the outcome would have been *their* responsibility. You're a cadet on her check flight, an unknown quantity, and they couldn't bring themselves to order you into something they didn't know you could handle."

"They sure let me volunteer, though," Jacinta pointed out.

"Sure. That's different, though you notice they didn't recall the two ERT flights. You can grab all the responsibility you can handle. But not one gram more."

Jacinta pondered that in silence; then she asked quietly, "What would you have done?"

"Me?" Chase snorted. "Just what you did. Not that I'm a hero or nothing, but they expect that kind of stunt from me."

Jacinta spun to face her screens. "Just living up to expectations, right?" she said lightly over her shoulder. He didn't fool her for one minute.

* * *

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Flaco Mercado was a bone charlie. He and his crew knew ziggy, so Jacinta had no qualms about seeing them jet off into the twisted entry to Solar Power Satellite Five. Or at least not many qualms. You sent the best you had, she realized, but bottom line, it was you that sent them. So whatever happened, it was you that shouldered it. Chase had been dead right about that part.

But he had been wrong about not being obligated to make the attempt, and not only because Adrienne was a friend and you didn't leave friends to die. It was because every otter in ziggy—from the Guangdong powersat crews who could not forget the asteroids their lasers were designed to burn to the pleasurers on FreeFall Sky Resort who did their best to help them forget—was a "sister under the skin," and she could not stand by, just doing her job, and watch when she could have made a difference. Failure didn't matter—except maybe to the Board. The one, true failure was not to try. STC had had to *order* Yungduk Morrisey to stand down and had ordered captain Zaranovsky in *Princess Shakhovskaya* to abort to LEO after he had already departed in Jacinta's wake.

When they entered the *Stine's* service module through the sidelock, Jacinta and Total found three otters huddled there already suited up and waiting. There was frost everywhere. The module had been powered down and the pressure lowered to the barest tolerable to conserve heat and oxygen. It was not until they had escorted the three across to the waiting *Bobbi Trout* and they had removed their helmets and taken a breath of reasonably fresh air that Jacinta realized that none of the three were Adrienne Coster.

She and Total sealed up their helmets with more haste than the situation required, yet less than their hearts demanded. They jetted across to the derelict *Stine* and squeezed into the command module and there she was.

Adrienne Coster had not even bothered to suit up. There was frost in her hair and her eyes and streaks of black blood had squeezed from nose and mouth and ear and around the edges of her ice-crusted eyes to float in small globules about the cabin. And all of a sudden, as if frozen words has slipped from those bloodless lips, Jacinta understood what it meant to accept responsibility for a ship.

"She could have suited up," Total protested over the suit-to-suit. "She might have made her suit air stretch. She knew I was coming. Damn it, why couldn't she have waited?"

Jacinta had no answer to that. It might have been that the *Stine* had lost too much air to begin with and there was not enough for four people to breathe. And it might have been that, having room for only three, Adrienne could not—or would not—choose between the two Guangdong otters in their nearly-exhausted suits. Or it might only have been the Board of Inquiry, where she might be found negligent or she might be found faultless but the one place she would not be found was back here among the crystal stars.

Jacinta tried to imagine herself faced with the choices Adrienne had faced and felt something cold and hard and heavy form within her. Something so cold she knew it would never, ever melt. "Did she leave any family behind?" she heard herself say. "Any loved ones?"

"Yes," said Total in a voice of distant grief. "Oh, yes."

Afterwards, when the ERT ships with their med-techs had rendezvoused and taken away the living and the dead, and Jacinta brought the *Trout* down, down, down to LEO once again and they docked at Goddard Free Port to the glare of websters and newsgroupies, she was asked again and again about her "heroic rescue mission." And again and again she tried to explain. How there had been no choice, really. And it was Flaco

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and his friend Tonio who had rescued the four trapped otters still alive. And Chase Coughlin and Kenji Yoshimura had juggled the complex logistics of bringing the others across. But try as she might, she could not explain that the real hero had been Adrienne Coster, who, whether she had blundered initially or not, *had* been faced with a choice and had taken the harder path. But it was not only responsibility for disaster that a captain must learn to accept. In the end, she found her refuge in a phrase she had heard to the point of self-parody from the lips of the man who had somehow become her mentor.

"I ain't no hero."

The newsgroupies went wild over it. The public likes their heroes in aw-shucks mode. No one seemed to notice what she really meant—that someone else had been the hero—and they wouldn't have believed it anyway. They had a paradigm to fill and Plucky Neophyte Rides to the Rescue was just what their readers and viewers and scrollers demanded. But Total knew. And Chase. And so Jacinta understood that—regardless how the Board of Inquiry or even the Examiners might rule on her performance—she wore the four stripes on her soul. Whether she ever wore them on her sleeve seemed somehow and suddenly a matter of no importance. ■

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***

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When the line between the real and the artificial gets sufficiently blurred . . .

STARSTRUCK

Grey Rollins

What I had was a good, old-fashioned case of the obsessions. Nothing new there. It's how the whole thing came about—that's the different part. It all started with me falling in love with an image on the silver screen.

It was spring, just barely warm enough outside to be comfortable. The sun was setting and it was nearly show time. We were congregating at Edward's house for the latest movie.

Mind you, this wasn't just any movie, it was a movie by Mark McClure. He didn't pop them out the way Paul did, or Maureen. Not Mark. He brooded over his creations, fiddling endlessly with the details; with the lighting, with the structure of the plot, the tilt of an eyebrow—all the millions of tiny things that go into making a movie. His movies were then, and still are, solid, dense, and rich to a fault. Even back then his movies looked nearly as good as the ones they made out in Hollywood, where they've got enough money to pay real programmers to write fancy custom software that can mimic the most minute details of human expression.

Once upon a time, they used humans to act out parts, but the humans got greedy and cantankerous and it got to be simpler just to write programs that created actors out of flickering pixels. When it got to the point that the entire movie was being created in a never-never land of bits and bytes, movies became cheaper to make. Then cheaper still as the software houses started making knockoffs of the big custom programs used by the major studios. Then even cheaper still as hardware prices fell.

Enter the era of the hobby movie maker. The local movie shop was called Through The Lens. They carried a fairly decent array of rendering software and some of the better hardware lines. They had the obligatory Thursday evening classes taught by one of the guys at the shop, where he helped you with lighting angles, special effects, and did a bit of programming to show you how to crank out odd bits of code to personalize the commercial software; making it just that little bit better than the off-the-shelf version.

I guess it goes without saying that no one at Through The Lens was any more than a technician when it came to making movies. It's like the guys who work in music stores; they've got a few good chops, they teach lessons, they sell instruments, but when it comes down to it, they usually just don't have that extra little pizzazz that makes the music sing.

But the local movie-making club . . . that was another story. Out of about sixteen or eighteen members, we had four who could actually crank out a movie with any regularity. Of those four, two were fair, one was actually pretty good—and then there was Mark.

We had as many saucer-eyed movie freaks as any other like-sized town. The

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usual percentage tried their hand at making their own. They bought the hardware and software, learned how to drive it, made a show, and called the gang over to see their latest magnum opus. Then, if they were lucky, they got a run in one of the public theaters downtown in the art district. Sometimes a talent scout would sniff around and take a report back to MGM or B-Entertainment.

Paul had someone from Warner Brothers showing interest in one of his movies once, but it never came to anything. I didn't think it was his best. I kept urging him to let them see *And Three Makes Two*, which we all agreed was a better movie. Somehow, the screening never came to pass, and that was the end of that.

Maureen, on the other hand, did actually get one taken national. Unlike Paul's, it was her best effort. Unlike Maureen, it was a good movie. I never did figure out how she managed to pull that one out of her hat. A couple of friends and I sat around drinking beer one night wondering out loud if she'd stolen the thing from someone. It wasn't in her usual style. She usually went for dark, atmospheric things, with lots of emotional turmoil under the surface. This was light and fast and it did so-so out in the world, making her enough money to eat off of for a few years.

But a Mark McClure movie, now that was a whole 'nother ball of wax. He was the only one who had what it took to go over the top into the big time. All he needed was a break. I kept waiting for the day when he'd pack his bags and head for California. Live in a big house overlooking the Pacific. Have hot and cold running maids. The works.

Maureen had had her chance, but Mark hadn't had his. His stuff was consistently good. More than good. That's why we all had such a sense of anticipation, knowing that we were going to get to see the first screening of his new film.

Edward had the best show rig around. He had spent a lot of money and it showed. Dedicated room, big screen, absolutely fabulous sound system. You name it, he had the best. Good movie, good system, good friends. It promised to be a splendid evening.

To make a long movie short, it was about a girl who moved to the city and had a bit of difficulty coping with the faster-paced lifestyle. Yes, I know, it's been done before. But so have love triangles, murder mysteries, science fiction epics, and war stories. Don't let my one-sentence synopsis put you off, see the thing for yourself. I laughed, I cringed, I even did my best to keep from sniffling out loud when her dog died. It was one helluva movie.

I cornered Mark after the movie to congratulate him. He was standing at Edward's kitchen table with a drink in his hand, basking in the glow of our massed adulation.

I pumped his free hand. "Damned good, Mark, damned good. If this doesn't get at least a lengthy run downtown, there's no justice in the world."

He cocked his head. "Can you put in a good word for me?"

I used to date the movie reviewer for the local news. Everyone assumed that I had an 'in' with her just because we were still on good terms. I chuckled. "For this movie, I'll even call Ellen. That's assuming that someone else doesn't beat me to the punch." I gestured through the archway into Edward's living room. "There are going to be a lot of other people talking about your movie tomorrow."

"But if Ellen hears it from you, she'll believe it."

I snorted. "I think your movie is perfectly capable of speaking for itself. All we need to do is arrange for a screening . . . and a box of tissues. Which reminds me, why'd you go and kill the dog, you bastard?"

He smirked. "Did you cry?"

"No!" I said, a little too quickly.

He just stood there looking at me

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with that smug grin on his face.

"All right, maybe a little," I confessed.

"Me too," he admitted. "It just seemed like the thing to do at the time. I almost took it out later, but decided to leave it in to make the ladies happy."

"*Happy?* Ann was about to have a fit!"

He shrugged. "For reasons which I've never understood, women like to have their tear ducts flushed regularly. If you let them cry a little, they're happy." He leaned closer and whispered conspiratorially, "I've always harbored the secret suspicion that women and men label their emotions differently."

I shook my head. "Mark, you're a cynical man, but for what it's worth, it does seem that the women here tonight liked it."

"Then I achieved my aim."

"And I liked it in spite of sniffling."

He gave me a speculative look. "Not because of?"

I gave him a stern look. "I'm a guy. I've got my emotions labeled properly. Stiff upper lip, and all that."

Mark nodded. "Well, I'm glad you liked it, either way."

Out of the corner of my eye, I saw Paul closing in. Not wanting to monopolize Mark's time, I added, "One last thing. I wanted to know if I could have a still of Debbie. She's awfully pretty."

Paul chimed in at my elbow, "Yeah, that's good code. Have you thought about selling a copy of your add-ons? I'll give you a good price. I could use a good female lead program and it looks like you've got the thing pretty well whipped into shape."

Just as Mark was about to answer, Angie closed in from the other side and started asking about the dialog. Within seconds the tide, which had been out in the living room, came flooding back into the kitchen in search of chips, drinks, and Mark. They found all three and settled in around the kitchen table, some sitting, some standing, just glad to be able to spend time with a man who had so much going.

When I got home that night, I belatedly realized that I had never gotten an answer as to whether I could get a still of Debbie. Oh well, no big deal. Just a pretty face. Her engaging personality probably came as much from the plot and circumstances as anything.

Only it *was* a big deal. Like the flu, coming on inexorably, by the next morning, I was beginning to realize that I had it bad. I kept thinking of things I'd like to talk to Debbie about, places I'd like to take her to eat, and yes, dammit, I wanted to kiss her.

I let it ride a few days, but then remembered that I needed to call Ellen and do my part to get some buzz started so that Mark's movie could go downtown and make him some money. He had bills to pay, the same as the rest of us.

Talking to Ellen stirred up my whole memory of Debbie. I fought myself, but gave in, calling Mark to tell him that I'd talked to Ellen about the movie, and that, with luck, she'd be in contact within the next day or two about seeing it. I brought up my request for a still again.

"What on Earth would you want that for?" he asked.

"Aside from the fact that I think that she's beautiful, in a girl-next-door sort of way, and charming, nothing."

He snorted. "Sounds like you liked her."

"Yeah," I said. "It's been a little lonely around here since I broke up with my girlfriend. It'd be nice to have Debbie to look at."

"I'm really proud of how her part turned out, so I'm a little protective."

"I'm not asking for the code or anything, just a still. You and Paul can duke it out as to whether you want to sell the code."

"Yeah, but then you'll want the code so you can build a personality module for your computer so you can talk to her. That's the kind of thing I'm not sure how to deal with." There was an edge to

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his voice that made me feel as though I'd pushed too hard, somehow.

I backed off hastily. "Sorry. Don't worry about it, then."

The whole thing snowballed with frightening rapidity. Within two weeks the movie was downtown. Maybe it was the press, maybe it was the lines waiting to get in, maybe it was just Mark's turn, but it went national by the end of the year.

Mark was almost never home any more. For that matter, he was almost never in town. Then came the inevitable day when his house went up for sale and he moved to Hollywood. No time for us small fry. Paul said the last time he'd talked to Mark, he'd been pretty egotistical. I guess it happens. It isn't as though Mark hadn't paid dues, and it wasn't as though he didn't have talent, it was just that I'd hoped that he'd remember us if and when he hit the big time.

He didn't.

Oh, well.

That would have been the end of it except . . .

Except they went back and put all of his earlier movies into national release in the second-run houses. And everybody went crazy over Mark McClure for a while. And with that much attention on him and his films the secret was bound to come out.

Debbie wasn't a program. She was a real person.

All the little things that had endeared her to me had worked their magic on others, too. In a world used to synthetic acting, the real thing was like a breath of fresh air. Debbie, and, oddly enough, her name was actually Debbie, was inventive enough to come up with things that random number generators couldn't duplicate. Between Mark and Debbie, they sparked a renaissance in real acting. It came out of left field so quickly that the commentators were left scrambling for things to say. Real actors went Hollywood so fast it made your head spin, albeit at less astronomical pay than before. Their attitudes and lifestyles? Read the tabloids and form your own opinion.

Debbie?

No, she didn't go Hollywood, at least not permanently. She turned out to be more of a catalyst than a reactant. The story of how she ended up in Mark's movie was really a series of accidents. Mark had been having trouble getting what he wanted for the role. He had fiddled with the programs he had for so long that he was seeing things. It just wasn't working. So he called on a friend. Debbie. He had her read the script aloud and improvise a bit if something came to mind. The two of them fine-tuned the part as they went. But the computers still couldn't capture that extra little something that she brought to the role, so after sweating a few details, he filmed her part and blended it into the rest of the movie.

The rest, as they say, is history. And so was Debbie. See, they had become lovers during all that intense creative movie-making. But when it was over, there really wasn't anything there to build a relationship on. When Mark went to Hollywood he left her behind, in every sense of the word.

Other than a broken heart, she really didn't mind as much as you'd think. She'd never set out to become an actress. It just sort of happened. Several people tried to cast her in other pictures, but it just didn't work out. For one thing, she was terribly shy. For another, she had no range. What you saw was what you got. The real Debbie.

Careers have been built on less, and they tried to build a few parts for her, but her heart wasn't in it, and she came home.

Me?

I made it a point to meet her. Was it difficult? Yes. She'd built a wall around herself to keep from getting hurt by nasty people who only wanted to use

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her. Did I persevere? Yes. I wouldn't have been true to myself if I hadn't.

Did I succeed?

Well . . .

It was raining, and I had gotten her out for what I thought privately was going to be the last time. I hadn't been able to break through her reserve, and I couldn't justify torturing her or myself any longer. But as long as we were out, I was determined to give it a gallant try.

There was this little Italian restaurant not far from the art district. It's still there. The food is good, the prices are reasonable, and the wine, let me just say that they serve the real Chianti, not the swill in the round, straw-bottomed bottles. Debbie was sitting across the table from me. It was only three or four feet, but it might as well have been the width of a continent. We just weren't connecting.

Instead of trying to get her to talk, to come out of her shell, I started talking. And somehow, it all came around to that scene in the movie where her dog died. And it hit me. The reason that scene had touched me was that it brought back the time when my dog had died, and as I talked, my eyes got a little misty. Enough so that I was glad that we were off by ourselves in a corner booth. And I talked about how it had hurt to lose my dog, and . . . and . . .

And I looked up at her, and she was crying. And all the hurt, and all the tension, and all the frustration that she had locked away inside of her over the last year all came flooding out.

I did the only thing I could do.

I reached across the table, took her hand, raised it to my lips, and kissed it gently, then held it while she cried. After a while, I reached over and dabbed gently at her eyes with a napkin, and told her that I'd always be there if she needed to cry, and for some reason that made her cry some more.

But then she smiled, and I don't think I've ever seen the sun look quite so beautiful after rain.

And I learned something in that instant. It's not that women have their emotions mislabeled. It's that they want to experience a wider range than men do. So I tried telling her a silly story about the time I went running after my dog and fell in the mud. She laughed. From the pits of despair, to the glory of laughter, all inside of five minutes. How women survive that kind of dipping and soaring, I'll never understand. It would tear the wings right off a man.

After leaving the restaurant, we splashed through puddles. We held our mouths open and let the rain dribble in. We walked down the center of empty, late night streets, just pleasantly tipsy enough to wave at the driver of a delivery truck that hissed past in the rain. In short, she began to relax. That was all it took.

So if I ever see Mark McClure again, I must remember to thank him for three things: First, for his movies, which won't surprise him. Second, for teaching me something about women, which probably won't surprise him, either.

Ah, but the third thing I'd like to thank him for is my wife—and that he won't expect at all. ▩

Institutions are in a moral sense impotent unless they are supported by the sense of responsibility of living individuals.

-Albert Einstein

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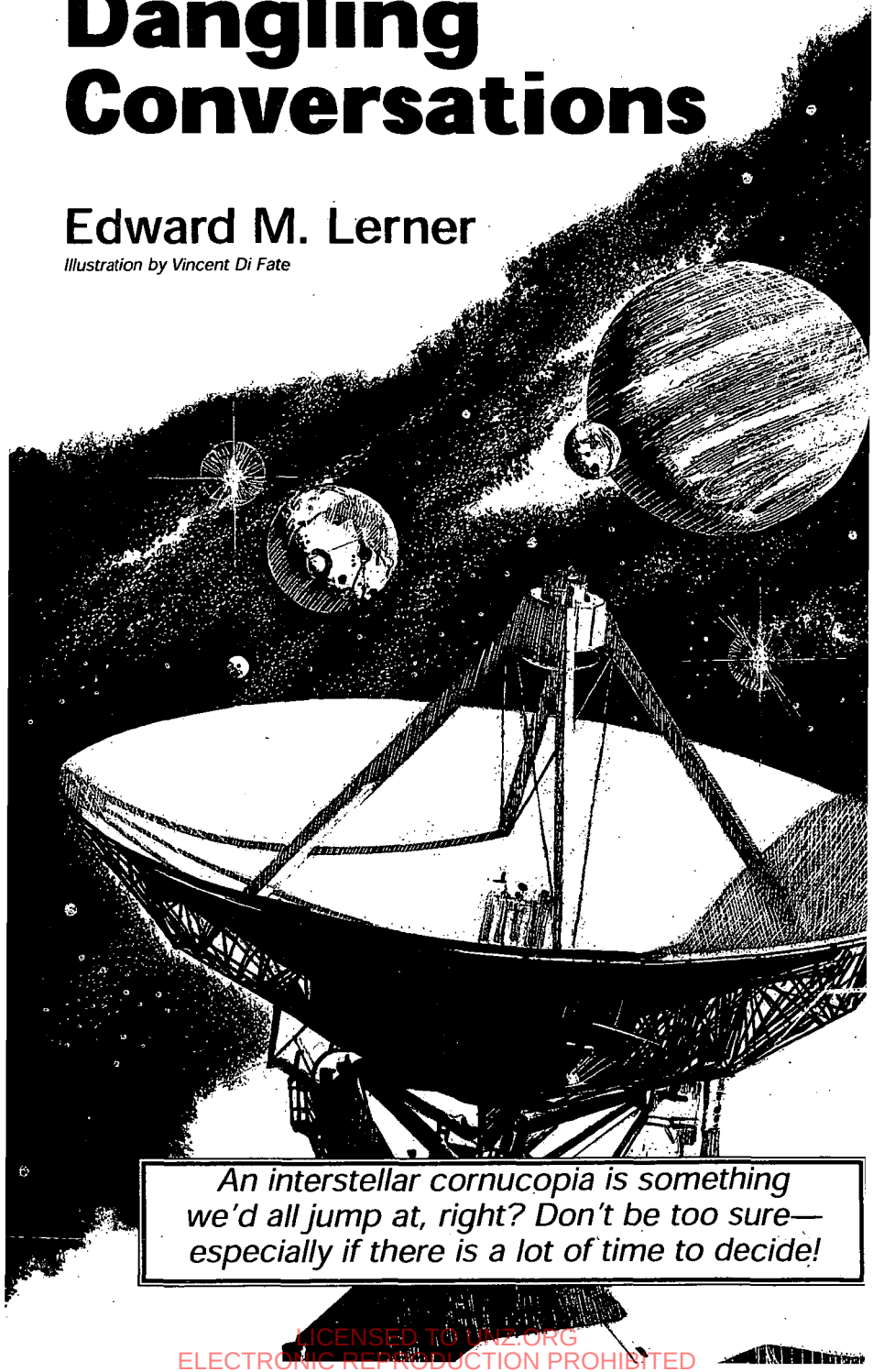
Dangling Conversations

Edward M. Lerner

Illustration by Vincent Di Fate



An interstellar cornucopia is something we'd all jump at, right? Don't be too sure—especially if there is a lot of time to decide!

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CHAPTER 1

Dom Perignon flowed and beluga vanished. A chamber orchestra played Bach. Crystal chandeliers sparkled and gold-rimmed china gleamed. An indoor fountain sprayed upwards around an enormous ice swan.

The ITU knew how to party in style.

From a terrace kept comparatively uncrowded by the chill evening breeze off Lake Geneva, Dean Matthews observed the gathering. Inside the hotel's Great Ballroom mingled dozens of international civil servants and hundreds of national delegates. There was an even larger number of "accredited industry observers." Matthews was one of the lobbyists, representing NetSat, a broadband satcom company.

Completion of a World Administrative Radio Conference *was* cause for celebration. New wireless technologies, and the implacable growth of older ones, kept the demand for spectrum high. For reasons of historical interest only, many radio bands had differing uses in different parts of the world: a big problem as more systems went global. Users of old systems were entitled to replacement bandwidth when new applications supplanted earlier frequency assignments.

The International Telecommunications Union took the lead in reconciling the many competing claims. That made the ITU an essential, if underappreciated, part of the global economy. Multi-billion-dollar fortunes rose and fell with the outcome of ITU negotiations.

A waiter glided by with champagne. Matthews took a flute for himself and one for his companion. "Congratulations, Madame Secretary-General."

They clinked glasses.

"You, too." Fair enough: the WARC had just authorized a frequency range for new broadband services that was compatible with NetSat's working prototype.

Bridget Satterswaithe, the Secretary-General of the ITU, turned to the lake. Great yachts bobbed at anchor, brightly lit by marina spotlights. She sipped her champagne. "Now that the conference is over, I look forward to some sailing. Maybe see my parents in London. Even a quiet. . . ."

Buzzing interrupted her; she retrieved the cell phone from her clutch bag. She appeared surprised at the caller ID on the display. "Please excuse me—I have to take this."

He took the stairs from the terrace down to the marina, giving Satterswaithe some privacy. Waves lapped peacefully against the shore. The wooden pier creaked under his tread. He, too, anticipated some well-deserved rest.

She rejoined him, sans champagne. She seemed shaken. "You're not going to believe why you won't be getting that bandwidth after all."

Dean held a Ph.D. in physics and an MBA in international trade. With ten years of telecom experience, he was, in Internet years, a grizzled veteran. As VP of Strategy and Technology for NetSat, his job entailed much more than lobbying the ITU and its national counterparts for bandwidth.

None of that experience prepared him for Bridget's news.

She had insisted that they go first to ITU headquarters, and would not discuss it—whatever *it* was—in the limo.

She now leaned against a corner of her desk. "This all becomes public knowledge tomorrow. It's been predistributed to governments and the appropriate international scientific bodies. I'm bending rules only slightly by telling you tonight. I'm doing so because, in one very narrow sense, the biggest impact will be on NetSat.

"Of course, life as we know it will also change."

She had his full attention.

Her call had been from the Secretary-General of the United Nations, parent body to the ITU. The International Academy of Astronautics and MIT were co-

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hosting a press conference in the morning. Dr. Sherman Xu, the discoverer, would give the first public announcement of a confirmed radio signal indicative of extraterrestrial intelligence. The ITU would immediately initiate an Extraordinary Administrative Radio Conference to fence off the frequencies used by the extra-solar signal.

ET must be using frequencies near those sought by NetSat. Despite his months of effort to secure the desired spectrum, the professional and personal impacts seemed inconsequential. Intelligent alien life!

Satterswaithe extracted a decanter of amber liquid and two glasses from her credenza. "The formation of a UN task force will also be announced, reporting to the Committee on the Peaceful Uses of Outer Space. Since ET uses radio, I've been asked to participate on behalf of the ITU."

He accepted a glass. "I have a terrific job at a world-class company. As of two minutes ago, that doesn't matter to me. This news is epochal. I want to be involved."

"My impression is that the team will consist of national government and UN personnel, plus academics. Sorry."

He canted his head thoughtfully. He'd been an RF engineer and systems architect before moving into management. He'd been a SETI (Search for Extra-Terrestrial Intelligence) enthusiast for longer. Perhaps he had the basis for an inference that would impress her. "Let's see what I know about ET that you haven't shared.

"I don't need to tell you that the universe is full of radio noise, or that most of that noise is outside the microwave band. At one end of the microwave window, at a wavelength of 21 centimeters, is the neutral hydrogen line. Hydrogen is the most common element in the universe, so the SETI folks deduce that's the radio-dial marker to listen near.

"The OH ion radiates nearby, at 18 centimeters. H plus OH equals H^2O: water. That's why the SETI crowd calls wavelengths between 18 to 21 centimeters the 'watering hole,' around which they theorize intelligent species will congregate."

He tested the liquid in his glass: an unblended Scotch. Served neat: without ice or water. "Of course, that's a water-chauvinist's perspective on SETI."

He knew that the SETI Institute had examined the nearest thousand stars at watering-hole wavelengths without success. He inferred a NetSat conflict with ET's signal, far from the watering hole. He hadn't read much about SETI work at MIT. All factors pointed away from a finding at the watering hole.

He rolled the dice. "I predict that ET's signal is about 6.7 centimeters: the hydrogen wavelength divided by pi." Pi was the only transcendental divisor of the hydrogen wavelength that could cause a conflict for NetSat. "That would be a good indicator of a signal from intelligent beings."

Her raised eyebrow confirmed his speculation.

"Where is the signal from?"

"Lalande 2-something. I hadn't heard of it."

"Probably Lalande 21185." The adult physicist had once been a boy with a four-inch telescope. A Web search agent kept him current at a hobbyist level with major astronomical news. "It's one of the stars closest to Earth, about eight light years. Near Leo Minor. It's been believed since 1996 to have at least one planet, Jupiter-sized."

She was silent for several minutes, making up her mind. "I can't promise anything, but I'll see what I can do."

Bandwidth alone didn't guarantee a successful satcom company—NetSat also needed to put its birds into orbit. Some of their launches were booked on Russian and Chinese boosters. That had meant obtaining licenses to export satellites to the foreign launch sites. And *that* meant Matthews knew people in the

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State Department.

The connection worked.

His assistant reached him on the flight from Switzerland. No need to dash across JFK for the plane to Washington: he had an urgent appointment in Manhattan with Alex Klein, American ambassador to the UN.

The diplomat was as circumlocutory as Matthews was direct. In some manner, it would seem, with vague attribution to the auspices of the Department of State, and in public-minded and full support of a recommendation from the Office of the Secretariat of the ITU, it would appear. . . . that Dean was in! He should expect an invitation to join the Lalande task force.

The implication was clearer that Klein's office was available to Matthews as a resource.

Unambiguous, if deniably oblique in its delivery, was the subtext that Dean should be forthcoming with any data of a "national security nature" that might arise during the task force deliberations.

CHAPTER 2

Held at a Caribbean resort, the kickoff meeting of the Lalande task force could have been mistaken for a corporate boondoggle. The remote island was far from most of the idly curious; a smattering of UN guards turned away uninvited members of the press.

The people at the registration table disavowed all knowledge when Dean had questioned the round red sticker on his name tag. It related, he presumed, to the as-yet undefined committee structure of the task force. Five colors were in use; no one whose name he recognized had red.

The auditorium doors opened, and the crowd surged inside. The Secretary-General of the UN gave the obligatory pep talk by satellite link. He introduced Kim Chun Ku, the Undersecretary-General for Administrative Affairs, as (the day's first news) head of the task force. The SG was followed by Ambassador Juan Roderigo of Argentina, currently heading COPUOS, the Committee on the Peaceful Uses of Outer Space.

Sherman Xu reprised his big announcement of two days before. The signal appeared to come from Lalande 21185. The carrier signal was at the hydrogen wavelength divided by pi. Like naturally occurring cosmic radio sources, the faint signal faded in and out. Unlike natural radio sources, the carrier was modulated with a narrowband signal, under 300 Hertz. About every 30 hours the signal included a sequence of pulses: pulse, pause, two pulses, pause, three pulses. . . . up to 128 pulses. That pulse sequence was repeated once.

A complex-seeming message followed the easy-to-recognize pulse sequences for thirty hours. The cycle then apparently repeated, although that conclusion was tentative due to noise and signal fading. His team hoped to have synthesized the full message within a week—if the signal persisted that long.

It was almost noon when Kim Chun Ku claimed the podium. Kim's remarks confirmed what his title plainly said: he was an administrator. His third viewgraph was an organization chart: five colored boxes. As one, the audience members glanced at their name badges. Whispered conversations erupted.

Kim tapped the mike until order returned, and he confirmed that colored stickers denoted committee assignments. After lunch, at committee breakout sessions, complete rosters would be made available.

The gold team, at the top of the chart, sounded like what Bridget had called the steering committee. Kim led the gold team. Membership included the leaders of the still undefined other teams, famous names from the SETI community, two assistants to ambassadors from COPUOS-participating countries, and a few UN agency heads like Bridget.

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Blue team dealt with radio engineering: signal acquisition and recovery. They would work with the ITU on reducing Earth-originated interference in ET's preferred frequencies, and coordinate among radio observatories worldwide monitoring ET's signal. Blue team was mostly radio astronomers, including Sherman Xu, with some of Bridget's staff thrown in.

Green team owned what struck Matthews as the part of the project most likely to be second-guessed: analysis. They were tasked with decoding and interpreting ET's message. Membership included lots of SETI folks, a codebreaker from the National Security Agency, mathematicians, and linguists.

Gray team would ponder Earth's possible response. Opening a dialogue with another civilization was not about science: this committee was entirely staffed by diplomats assigned by the Security Council. Mathematicians and linguists from Analysis would encode Earth's message after a reply, if any, had been strategized.

And the red team? The best had *not* been saved for last.

Red denoted the media and education committee. They were to coordinate the release and positioning of everyone else's results. Red team would also field questions and unsolicited suggestions. Matthews' teammates were pool reporters, PR flacks, educators, and—oh, joy!—a multicultural behavioral response team.

Why was he on the red team?

"And so," concluded Paul Ricard, "our role is to package and control the Lalande information, while respecting various cultural sensitivities. After a short break, I propose to discuss process concepts for that mission."

The red-team leader had spoken for twenty minutes, without conveying any more than his summary. The viewpoint was what Matthews expected from a PR flack, even one with a prestigious UN title. Dean cleared his throat.

"Dr. Matthews, have you something to add?"

Unfortunately, he did. "Yes, actually. I don't think our charter, as you've spelled it out, can be accomplished."

"Why is that?" Ricard was more condescending than curious.

Matthews had sensed, when the session opened with brief introductions, that he was not alone in wondering about his assignment. As he had suspected, Dean was the only member with a physical-sciences background.

"We don't have a monopoly on ET information." The media reps, who were being mysteriously docile, seemed to suffer from the misapprehension that task-force membership guaranteed a lock on all Lalande news. "If we withhold or spin any findings, we'll discredit the whole task force."

"I question the premise." Ricard was miffed. "We've brought into the task force the leadership of every major radio telescope. Surely we can rely upon their cooperation in the responsible release of discoveries."

Irrelevant, even if true. "In days, universities worldwide will be monitoring ET directly. They can easily build an adequate receiver from arrays of commercial satellite dishes. Thanks to Dr. Xu, they know exactly where to point the antennas and the frequency to tune to. And they'll *all* be racing to post observations and interpretations on the Web."

Many surprised looks were exchanged about the room before Ricard found his voice. "How sure are you about this?"

"Very. As you know, I'm on leave of absence from a satcom company, one of many such firms. Any of a dozen people from my former staff could do this."

"Dr. Matthews?" asked Amreesh Shah, a psychologist from the behavioral-response group. "What would you propose?"

"Publish our observations rather than filter them. Clearly mark as commentary

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any 'adjustments' we may choose to make.

"While we won't have a monopoly on the signal, we will have resources far beyond those of other listeners. If our postings are prompt and objective, our interpretations insightful, *we* become the preferred source of ET data. If we hold back, however well-intentioned our reasons, the best we can hope for is marginalization by other news sources. At worst, who knows what motives will be ascribed to us? There's no shortage of people who see conspiracies all around them."

Shah nodded. "Distrust is the result we can least afford."

That was one point everyone in the committee agreed upon.

From the SETI Conspiracy chat room.

Suspect_Everyone: Does it strike anyone else as suspicious that the UN is orchestrating the Lalande investigation?

UFO_believer: Absolutely! And who's behind this "International Academy of Astronautics"?

42_is_true: I'd sure like to see the ET message text from a reliable source, not the US government, and *certainly* not the UN.

Suspect_Everyone: Does it strike anyone else as suspicious that it's suddenly hard to buy satellite dishes?

Bridget idly flapped the paper umbrella from her tropical punch. Open, close, open, close. "Quite a meeting."

Satterswaithe was an electrical engineer by training, with a Ph.D. from Oxford. She'd gone straight from university to a British government research establishment. That had been a stepping stone to the ITU, which, after a succession of promotions, she now headed. An adult life spent in bureaucracies had not diminished her determination to make things happen. She had, however, developed a tolerance for committees that Matthews could not fathom.

Dean favored a local beer he'd discovered on the first night of the kickoff. Delightful microbrew notwithstanding, he was eager to get back to the States. He and Satterswaithe had met in the airport bar, awaiting their separate flights. "It turned out okay. Maybe I'll cancel the mob contract I took out on you."

"For accomplishing what you pleaded for?"

"Requested in a dignified manner." He gestured for another round. "No, for putting me with the social scientists and spin doctors. Look, I respect their sincerity and good intentions, but I've *never* met so many people who see the glass as half empty."

"Don't blame me or the gold team. Yours was one of the few assignments Kim had made before Steering even met." A boarding announcement from a staticky PA drowned out her next words.

"What?"

"I asked, 'So how is it that things turned out okay?'."

"Had it been my choice, I would've had a tough time deciding between Signals, Analysis, and Reply. It occurred to me that someone on the red team has to liaise with those other committees. A technically oriented interfacer made sense. So I've gotten myself access to all of the information that Steering has, without, no offense, enduring all of that bureaucratic ponderousness."

"No offense taken." She laughed. "Well, maybe a little. In any case, I'm off to my gate. I'm glad it worked out for you."

He decided he was glad for her abrupt departure, which avoided the awkward question about who, since it wasn't the steering committee, wanted him on the Media & Education team. It couldn't have been Kim's idea: Kim knew nothing about him.

At least the undersecretary-general was unlikely to have heard about Matthews absent input from the US ambassador.

* * *

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From the Earth First chat room.

All_Politics_Is_Local: So what's with the Lalande task force and its closed-door "organizational" meeting?

Stop_World_Government: What's the UN *always* up to? ET's message is simply another excuse for worldwide government. Whatever the task force is for. . . . I'm against.

All_Politics_Is_Local: It's welfare for rich-country scientists. Would a Bangladeshi textile worker think this is the best use for the money?

Radical_Dude: There's common cause among world-government resistors, ET skeptics, and third-world advocates. Expect the UN to get a taste of what we gave the WTO in Seattle in '99.

CHAPTER 3

Alex Klein had alerted Dean to the unadvertised coordination between the Russian and American militaries and the steering committee. One thing led to another, and now Matthews was at a Manhattan deli with a Russian general and ex-cosmonaut.

Vladimir Grigorivich Antinov began his career in the Red Air Force. He'd been an advisor to Hanoi during the Viet Nam War, a time he declined to discuss. He'd gone on to, and risen rapidly in, the then-Soviet Strategic Rocket Forces. Combining piloting and missile expertise, he'd moved into the cosmonaut corps. He'd served two tours aboard *Mir*, one as mission commander. His English, from years of joint planning with NASA, was excellent.

After an exchange of pleasantries and the ordering of lunches, Dean got to the point. "To be honest, I'm surprised that the militaries care about ET."

Antinov dumped sugar into his tea. "Our job is to worry."

"About what? ET is *far* away."

"That is an assumption it is best to validate."

Arrival of their sandwiches gave Dean a chance to consider Antinov's rebuttal. ET's signal was quickly recognized as artificial because of the pi factor. That observed wavelength, however, depended on the wavelength originally transmitted *and* Doppler shift due to relative motion between sender and receiver. Lalande 21185 and the sun moved relative to each other. ET's unseen planet must, like Earth, orbit its sun and rotate about its axis. The signal should have wobbled continuously around its "look at me" wavelength.

It didn't.

Without any decoding of content, this observation showed that the message was intended specifically for Earth. It meant that ET saw Earth well enough to measure its orbit and rotation, and then dynamically tune his signal accordingly.

"In ten years, *we* could have a telescope able to resolve Earth-sized planets of nearby stars," said Dean. "NASA has requested funding for one for years. ET seeing Earth doesn't require technology much past ours."

Antinov waved over the waitress to refill his cup. "Or ET could be much closer. If he can correct a signal for planetary motions, his and ours, he can as easily compensate for blue shift to disguise transmission from an approaching vessel."

"But why announce your existence *and* hide your arrival?"

"The message may announce a visit. We can't read it yet."

Might ET be announcing his arrival? Matthews shoved away his plate, half of a corned beef on rye untouched. He'd heard nothing like this from anyone on the task force. "Since we're discussing this in a deli, you can't be too concerned."

"Did I have too much fun with you? I will explain what my people and yours are doing: probing with our most powerful radars along the signal path. These radars can detect the smallest bits of space junk in Earth orbit. We can track a dropped bolt that is hundreds of kilometers high. More than once," the cosmo-

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naut smiled, "that has been a useful capability. We would expect to detect a starship *much* farther away. As yet, there has been no return pulse."

Matthews had never worked with military radar, but thought he could make an intelligent guess at its sensitivity from an understanding of radio telescopes. "If ET is coming, he's still well outside our solar system. Or stealthed."

Antinov winked at the mention of stealth. "I commend your newfound paranoia, though in this case such caution may be excessive. To visit us, a vessel must travel at very high speed through the scattered matter that makes interstellar space only a *near* vacuum. Could a ship maintain stealthiness against the ongoing particle bombardment? Would it not radiate, whether from collisions with such particles or some protective force field? We've seen no such evidence.

"We've even used the comet watcher trick of flipping back and forth between telescope photographs taken on successive nights of the same part of the sky. There are no unexpected moving objects, nor any unexpected occluded stars."

"You *have* been busy."

"We do only what your Space Command has done, I think."

Matthews grabbed the check. "So are you convinced that the signal is genuine, and from Lalande 21185?"

"It has been a most pleasant discussion, but duty calls." Antinov stood. "As for your question, I am *almost* convinced.

"I am entirely certain that were ET able to sneak up on us, nothing we could do in preparation would matter."

CHAPTER 4

". . . .And still no comment from the UN investigation. Has ET's signal been lost? If so, what does it mean? Is the UN covering up? We want to hear from you."

The radio call-in show was Dean's regular breakfast companion, entertaining when he successfully compartmentalized the sorry implications about the state of education. Today's show was annoying rather than amusing, however—even though, oddly enough, it had the facts mostly correct.

The signal from Lalande 21185 *had* vanished last night.

He retrieved today's paper from the curb. Loss of signal was front-page news, with attribution to the SETI Institute, the Planetary Society, and Cal Tech. As he'd foreseen, universities and science-interest groups had built their own antenna arrays—and they were free to announce findings when they pleased. That usually meant only a phone call to a buddy at a peer institution to confirm an observation or analysis.

He'd phoned Ricard after getting an alert from Signals, urging the committee head to issue a statement. Ricard instead ruled that the matter needed a Media & Education consensus recommendation to the steerers. Damned committee process!

He stuffed the paper into his briefcase. There'd be time for it on the shuttle to New York for the emergency meeting.

The early work of Media & Education had lulled Matthews into a false sense of security: the task force's original findings were uncontroversial, and so quickly released. For those first few days they'd also had a monopoly on signal reception.

Things started changing once independent observatories came on-line and the bulk of the repeating message was posted to the Web. Now the task force was in a race with every other interested party to interpret ET's message.

That message started simply enough: two pulse trains counting from one to 128. Next came hours of data without apparent pattern. The analysts soon rec-

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ognized that the data immediately following the two pulse trains of 128 was a two-dimensional, 128-by-128 pixel image. The image was simple but informative: sets of tick marks, from one to sixteen, each set paired with alien symbols. ET was communicating by what amounted to facsimile transmission, he counted in octal, and he had shown Earth how he wrote his numerals—a quickly approved press release.

The bottom left corner of that first image carried ET's symbol for one: he was enumerating images. The bottom right corner bore two numbers: 128 twice. As suggested, the next part of the message could be read as another 128-by-128 image.

Subsequent images were easily recognized as math lessons, building a common mathematical vocabulary. None of the symbols matched human conventions, of course, but there were no surprises at that early stage as to message meaning. The committee had little difficulty drafting a press release citing a shared view of arithmetic.

Contention arose with the next few images, perhaps not coincidentally because an undergrad physics major at the University of Calgary was first to interpret them. She identified one drawing as a spectrogram, an energy-intensity versus frequency plot, of Lalande 21185. The next graphic was a similar spectrogram for the Sun.

Beyond confirming the source and destination of ET's communication, those images introduced two new symbols: us and them. The solar spectrogram had one other novel aspect: a corner annotation indicating that a 3-D dataset followed. The 3-D dataset appeared to be a series of spectrograms, successively more crowded, but otherwise mysterious. The net effect was a crude animation, like a child's flip book. The meaning of the dataset's third dimension remained unclear. Intriguingly, each 2-D slice bore the symbol for "us."

The committee was slow to comment on these images. The media types (and Matthews agreed) proposed simply stating that two new symbols had been decoded, but that the following dataset was not yet understood. The behavioral-response contingent thought it necessary to put these findings "into a suitable context" to protect fragile human egos. "To those countries that were recently colonies of the West, 'us and them' distinctions are sensitive matters," was one Third World sociologist's assertion. The behavioral-response folks were further concerned that an admission "'we' had failed to understand" a dataset could make humans feel inferior to, hence threatened by, ET.

Matthews just didn't get their point: "us" and "them" were just pronouns. An undecoded dataset so early in the effort also failed to faze him. . . . why should ET's message be immediately clear? ET was *alien*. They waffled for two days, by which time the external media had moved on to newer news.

Waiting for the emergency meeting to start, Matthews wondered if the committee had learned its lesson. The loss of signal was already widely known; he felt they should just acknowledge it.

Ricard had inexplicably brought a gavel, which he wielded to open the meeting. Some overseas members, unable to join the short-notice session in person, were videoconferenced in by encrypted network link; they winced as the chairman pounded too close to the mike.

"Thank you all for coming." After excessive pleasantries, Ricard came to the point. "It has been reported that the signal from ET has been lost. The matter being so important, we will discuss a suitable statement for recommendation to the steering committee." Heads nodded.

"Point of clarification," interrupted Matthews. "A more precise statement is that the signal has ceased. Every observatory, government-funded and other, reports the same thing." He'd been on-

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line for much of his flight; the message boards were unanimous about the time that the signal had disappeared. It hadn't faded or been randomly garbled by cosmic interference, both of which had often happened. The signal was just *gone*.

"Do we know why?" asked someone.

"The short and honest answer is: no. On the 'net, the most common guess is that ET's orbit is bringing him to the side of his sun opposite us, so he's stopped sending until he can get a clean signal through again. Perhaps, once we've decoded the entire message, he'll have told us."

In a pleasant surprise, reason won out. The not-too-tardy press release simply reported the cessation of transmission.

"You've got incoming."

For a Brit, Bridget had a fair grasp of American slang. Matthews still reserved judgment whether he had cause to worry.

He was nonetheless suspicious. It was eight in the evening for him, making it the middle of the night in Switzerland. Moreover, she'd contacted him over the 'net, and Internet telephony had far lower voice quality than a normal call.

The task force had provided its members with PC-compatible encryption devices of unusual robustness, which he guessed she wanted to use. That turned out to be correct.

"What's up?" he asked once they'd opened a secure session.

"You know there are ITU staffers on the Signals committee. One gave me a sneak preview of their latest finding. You'll surely hear all about it in Media. Judging from the tizzy your friends got into over 'us' and 'them,' this news is sure to throw them for a circle. A heads-up seemed in order."

For a *loop*, he thought to himself. "What is it?"

"Watch."

She opened two windows on his PC. In a red window she ran the animation of ET's "us"-labelled spectral flip book. The other window, colored green, showed a similar sequence of images. She slid the second window over the first, and reran them superimposed. The green charts were in all cases a superset of the red.

"Green is our best-guess reconstruction of Earth's aggregated RF emissions over time. The big energy spikes are from TV transmitters and ballistic missile early warning radars."

"When does your animation start?"

She grinned at him from the corner of his screen still showing real-time video. "The best fit matches ET's spectrum animation with our reconstructed data starting in mid-1950."

She had used the term "incoming" correctly: ET had lobbed a figurative bombshell at them.

Apropos of the New York venue, it was *déjà vu* all over again: another short-notice Media meeting. So far, only the task force had the explosive news. If Media moved quickly, this time they could shape the world's impressions.

ET had in 1958 captured signals emitted by Earth in 1950. He'd waited more than thirty years to respond. Why?

"It's devastating," said Dr. Shah, a psychologist, "that ET could not be bothered to answer. Are we so insignificant?"

Thanks to Bridget, Matthews had had a day to ponder the matter. "A purposefully delayed response is not the only explanation. Perhaps ET is just explaining how Earth came to his attention. His radio astronomers might routinely capture and save radio energy from neighboring stars, and not have immediately recognized our 'signal' "—he waggled his fingers as exaggerated quotation marks—"for what it was.

"ET sent us a systematically constructed message, much of which we almost instantly understood. He sent it at very high power levels. Whatever signal he's gotten from Earth was *much* weaker, unintended leakage from TV and radio

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and military radars. None of that was designed for him to recognize or decode. I'm guessing, but what may have eventually convinced him that we're here and aware is the rapid increase in power levels and in frequencies being used. I doubt ET extracted any meaning from the mish-mash."

Dr. Shah imitated Matthews' earlier gesture. "About those quotation marks. . . . what did you mean?"

"The signals ET received from us were *very* faint. 'I Love Lucy' was not meant as an interstellar communication. If ET's signal were as low-powered as what Earth emits, we'd never have detected it."

Michel Margot, a Belgian sociologist, broke the thoughtful silence that had come over the committee. "You suggest that we can't know how long ET delayed after suspecting our presence."

Matthews nodded.

"But his radio technology is more advanced than ours."

"Correct."

"But not greatly more advanced, or his response would likely have come sooner." Margot took Matthews' silence as assent. "That's good. There could be an adverse reaction to a perceived technology gap." To the group, the sociologist added, "This seems a responsible position to articulate."

Heads bobbed in what Chairman Ricard mistook for unanimous agreement. He assigned a writer to draft a press release.

The phrase "not greatly more advanced" contained a significant degree of ambiguity. ET had radio receivers in 1958 exceeding any Earth owned today. His high-power transmitter was a marvel. In the interest of an announcement more devoid than usual of spin, Matthews kept to himself the thought of how much he'd like to obtain ET's radio technology.

"In the General Assembly today, the Secretary-General of the United Nations urgently requested an emergency supplemental authorization. He stated that the UN's budget has been unusually strained by peacekeeping duties across the Balkans, sub-Saharan Africa, and the former Indonesia. He pointed to growing requests for humanitarian assistance by the UN High Commissioner on Refugees. The Lalande 21185 task force was also identified as an unanticipated expense.

"Third World delegates responded skeptically, suggesting that the UN reallocate scarce resources to its core missions. The ambassador of Congo spoke for many of his peers. 'What is the use of an arithmetic lesson from the stars? How many AIDS vaccinations, how much famine relief, could we provide with funds we are now squandering on ET?'

"Rising polarization on the subject of funding for the Lalande investigation seems certain to conflict with the proposed international treaty on interstellar communications. The treaty, recently passed by the General Assembly and awaiting ratification by member states, requires that any response to ET come under UN auspices."

—BBC World News Service

CHAPTER 5

"To ET."

Matthews rarely toasted with iced tea, but Barbara White seldom drank anything stronger. Barb stood five foot zip in high heels; she said her tolerance for booze was best measured in thimblefuls.

"To NetSat."

Barb was CEO and founder of that company. He had been employee number four before going on leave of absence. They went back a long time together.

It had been a chance encounter at the shopping mall. They'd retreated to the food court. "Is ET still being mum?"

"Yup." He bit a taco. "Not that it could be kept secret if he began talking

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"Yup." He bit a taco. "Not that it could be kept secret if he began talking again. In any case, it'll be a while before we understand what he already had to say."

"So when can I expect you back?"

"I can't tell yet." Pause. "Not till we're done."

She knew him too well. "What's the problem?"

"What we're learning is astounding. For example, ET's replay of what he received from Earth will teach us a *lot* about radio propagation across interstellar distances. And I work every day with brilliant people."

"There's a big 'but' in there somewhere."

"Think of the most bureaucratic dealings you've ever had with the government. This is worse. On top of a clumsy committee process, we've got all of the international politics. Amazingly, most prospective announcements get inanely entangled with nineteenth-century colonialism and worries about possible Third World misperception. Apparently our paramount mission is to build up humanity's self-esteem."

"Then come back to NetSat. I need my chief strategist."

"Barb . . . . let's not go there. This work is too important."

It wasn't the answer she wanted. She brightened as a safer topic came to mind. "Hey, I owe you a compliment. Your recommendation paid off."

Dean guessed she meant the wrap-up memo he'd written on his way out the door at NetSat. He had a visceral dislike of loose ends. "The constellation reconfig?"

"The same. As you proposed, it was an easy software fix to keep our satellites and ground stations from broadcasting directly on a Lalande 21185 line of sight. We'll lose a little capacity, but we maintained our launch schedule. It *sure* beat trying to start over on a new frequency to accommodate your ET buddies. That could've put us out of business."

"I'm glad it worked out."

Her wristwatch beeped on the hour. "Gotta run. Listen, it was great seeing you, and I *do* want you back sometime."

After a goodbye hug she left and he finished his late lunch. The conversation had put an unaccustomed monetary perspective on the task force's work: the cost associated with foregone use of spectrum. That was in addition to the cost of investigations, UN-sponsored and other, about which several countries were already complaining.

The epiphany came during his last taco. How about *ET's* economics? Even without knowledge of how ET allocated resources, it stood to reason that ET had made a major investment to contact Earth. His transmitter, and its power requirements, had to be enormous. For how long would his society, whatever form that took, be willing to operate it? Was *that* why ET had gone off the air?

Congress cancelled NASA's SETI program in 1993, when the agency was only spending about a nickel per taxpayer on the effort. Luckily, some private institutions had ponied up the money to keep the search alive. Many developing countries were now objecting to UN funding of the task force. Would ET's society work any differently?

There was a new urgency to decoding ET's full message, and answering while, Matthews hoped, ET was still listening.

CHAPTER 6

With intellectual discipline that many found intimidating, ET's message continued to expand a common vocabulary. Some speculated that much of ET's delay in responding had been time spent formulating the elegant reply.

Animations of motion introduced mechanics and ET's notation for the calculus. Cartoons of atoms with emission spectra identified elements and ET's symbols for them. Cartoons using the element symbols showed simple molecu-

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lar representations, which were used to illustrate a simple chemical reaction. An image of a simple wet cell labelled with its chemical reaction provided a symbol for voltage, beginning a review of electrical engineering.

The purpose for all of this common vocabulary was still unknown when the task force was summoned to present its status to a philosophically-divided COPUOS.

"The Committee on the Peaceful Uses of Outer Space will come to order." Ambassador and chairman Juan Roderigo, although Harvard-educated, spoke in his native Spanish.

Only the steering committee had been invited, but Bridget had wangled Matthews a guest pass in view of his liaison duties. As a guest, he was expected to observe silently. He donned an earpiece, wondering how long it would take to adjust to English in one ear and whatever in the other. English was the worldwide language of technology, trade, and air traffic control; diplomats had no such standardization.

Undersecretary-General Kim spoke for his task force. The message summary passed quickly, boiled down to the diplomatic level of scientific literacy. Bobbing heads around the horseshoe-shaped table suggested that the summation had been understood. ET heard us; after an unexplained delay, he answered; he was now building a common vocabulary with us.

Roderigo paid the obligatory compliments to Kim for the hard work of the task force. The ambassadors from the US, Russia, Japan, Peru, and several western European countries followed suit. Then the manure collided with the ventilator.

Maurice Mbeke of Congo spoke in fluent French, but the ambassador's message, like his dashiki, was distinctly afrocentric. "I think—no, I know—that I speak for many others in asking why the aliens have expended so much effort in communicating with us. We will resist interstellar colonialism, physical or cultural."

Matthews was not entirely surprised: this was a perspective with which Matthews had become familiar, though not accepting, from innumerable discussions of the Media & Education committee. What did take Dean aback was the level of support Mbeke had. Speaker after speaker, especially from the nations who'd recently joined COPUOS, endorsed what Matthews thought was a head-in-the-sand view of the situation. To the physicist's astonishment, even some industrialized countries shared a concern about ET.

The Russian ambassador, Anatoly Shuskov, took the floor. "I ask the indulgence of the committee to have a distinguished member of my staff comment in my place." Once permission was granted, Shuskov ceded the floor to General Antinov.

"Ambassadors, thank you for hearing an old soldier. I am proud to have defended the Soviet Union for many years. I am proud to have taken part in Russia's transition to democracy. As a past member of the rocket forces and the cosmonaut corps, I believe I have credibility in defense and space matters.

"Ambassador Shuskov asked me to assure the committee that our forces have searched for evidence of coming aliens. We found no such evidence. As a cosmonaut, however, I tell you frankly: if ET did visit us, it would mean that his technology exceeds ours as an aircraft carrier exceeds a sailboat."

The simile came painfully close to accusing ET of gunboat diplomacy, a comparison not lost on the Chinese ambassador. Matthews wondered whether the association was intentional.

"I am known for being direct. If ET can come, and opts to, he will. Nothing we say or do will stop him. If ET wishes only to talk, we may choose to listen. I urge COPUOS to listen.

"It is better to know what ET can do

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than to not know." His eyes swept the committee. "I will state clearly what most only hint at: some nations have had cause to fear the superior technology of others. Where nations differ has been in their response to that challenge. Those who learned eventually prospered. Those who clung to their old ways soon suffered."

Pausing for a sip of water, Antinov studied his audience. Some of the former certainty was gone from their faces. "Nothing this committee can do will reduce the risks of new knowledge. You may decide not to listen to ET, but you cannot stop other countries, universities, corporations from listening. From learning. You may hope to keep ET's message from your society. You will be no more successful than you were at keeping out blue jeans or rock-and-roll.

"I give you a final thought. The cost of restricting knowledge is onerous. It takes a police state to even try." He smiled sadly. "We Russians learned that lesson well.

"And to bear the burden of such restrictions, only to see other countries master new technologies from ET. . . . that would be *truly* a tragedy."

". . . .So since *we* were made in God's image, some bug-eyed thing across the galaxy can't be one of God's creatures."

"Interesting point, Rick," said the deejay. His enthusiasm sounded forced.

"The way I was taught, God sent his only begotten Son to redeem us. Jesus died for our sins, right here on Earth. That tells me that ET must be damned."

"As a good Christian, is it your duty to bring Jesus' message to ET?"

"You're not listening. They're not in God's image. They're damned. In my book, that makes them devils."

When COPUOS reconvened for a second day of hearings, the opponents of the task force had fine-tuned their approach. No one sought to rebut Antinov's defense of listening. Perhaps it had registered that ET was no longer talking.

The skeptics today turned to exaggerated praise. The task force had done the hard work and ET's message was in the can. Anyone who was interested was welcome to finish deciphering the message.

Oh, yes. . . . and please leave your budget at the door.

There was a whispered consultation among the steering committee, sitting behind the long table set across the open end of the horseshoe. Bridget grabbed a mike. "We need still to talk about the Reply committee."

By prearrangement among the developing countries, today Ambassador Smythe of Belize led the attack. "ET learned we are here. He told us he is there. What's the added benefit of exchanging postcards?"

"I feel that acknowledgement is the least we can do, Madam Ambassador. ET has shown us the extraordinary fact that we are not the only intelligent beings in the universe. I also believe it is in our self-interest to maintain and enhance the dialogue. We have so much to learn."

"Surely the least we can do is nothing." Several ambassadors smiled. "We can discuss proper interstellar manners on another occasion. I'd rather you expand on your second point. I'm struck not by how much we can learn but by how little. The task force has diverted some of the world's best scientists to a rediscovery of arithmetic."

Bridget squirmed in her chair. Perhaps she felt sandbagged by the lack of Commonwealth solidarity from an official of a former British colony. "Madam Ambassador, I think that summation gives insufficient credit for our work. We have made great progress in building a common vocabulary."

"What indication has ET given of having anything to say?"

"We haven't finished reading his message."

"Which is to say, none." Smythe smiled humorlessly. "And what conclu-

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sions has the Reply committee reached on an answer from Earth? I believe the answer there to be the same."

Bridget squared her shoulders. "Again, I could refer to interim progress. Surely it is not unreasonable to take some time in deciding how to respond to a whole new civilization."

"What can you tell me about this civilization? What do they look like? Do they breathe oxygen? Are they ruled by parliaments or potentates?"

"The part of the message we've decoded does not address cultural and biological matters."

The ambassador checked her notes. "Can you say what planet of their sun they live on?"

"No."

The steerers looked down at the table or around the room, everywhere but at the two debaters. Matthews, seated behind Bridget in the visitors gallery, seethed.

"In fact, ET's signal intentionally hides all evidence of the planet he's from."

"I believe that to be a mischaracterization of why the signal is at a constant frequency," replied Bridget. She was also starting to get angry.

"But ET has not shown what planet he's from, even though he's shown he knows what planet *we* are from."

"Not in what has been decoded so far."

Smythe looked to her colleagues. "We staffed the Reply committee with veteran diplomats. It is no surprise to me that they have no draft response. How *could* they reply to an alien race that has offered absolutely no information about itself?"

If Bridget had seemed angry by the end of the exchange with the ambassador from Belize, Matthews was furious. The questions had all been variations of, "Do you still beat your spouse?" Any direct answer was either an admission or an apparent evasion.

Bridget had, quite properly, pointed out that ET's message was only partially analyzed. That worked fine once or twice; after that, it came across as an excuse.

He gave her credit for maintaining her composure. Perhaps there was no politic way to tell an ambassador that she was full of crap. Antinov's performance yesterday had been one of a kind, and only his unique career allowed him to pull it off.

Roderigo called a recess. The ambassadors converged to one end of the room; the steerers huddled at their table. Matthews felt alone in a crowded room, watching COPUOS move towards declaring victory and disbanding the task force.

No COPUOS action could stop analysis of the message; ET's full text was on the Web for all who cared to see. There were also plenty of antennas beyond task force jurisdiction listening for the resumption of ET's signal. A UN withdrawal of funding, if it happened, would only slow the analysis.

No, the real problem would came later, *after* the analysis. It was not merely appropriate for Earth's answer to come from the UN level. Two days after Xu's press release, the General Assembly had passed an emergency resolution. With its hasty ratification by three-fourths of UN member countries, an international treaty now required that any response come only under UN auspices. Mbeke, Smythe, and their ilk showed little interest in okaying any such transmission.

Protocol be damned. Matthews started pushing through the crowd to the American ambassador.

Alexander Klein had an imposing resume. He had earned Ph.D.s in history and international studies from Yale at 22. He was tenured at Stanford at 27. At thirty, he was a senior staffer on the National Security Council. The UN ambassadorship was his second cabinet-level position.

Klein overruled the aide attempting

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to shoo Matthews away. They stepped into a small chamber off the COPUOS hearing room. The ambassador heard Matthews out, asking occasional questions and jotting notes. Glancing often at his watch, Klein kept the conversation ruthlessly focused: absent a compelling new argument, the hearing was moving towards shut-down of the task force. Matthews hoped he was making that case.

Roderigo's gavel fell. Ambassadors, witnesses, staff and observers all took their seats. The chairman recognized Klein.

After a flowery introduction, Klein took some notes from his jacket. He rubbed his chin thoughtfully. "Dr. Satterswaithe, might I impose on you for a bit longer?"

Bridget nodded.

"I'd like us to step back from the text of ET's message, or rather from the part of that message so far decoded. I've been led to believe that it might be instructive to consider the broader context."

Klein glanced again at the notes of his consultation with Matthews. "Would I be correct in understanding the following? In just the last few weeks we've been given proof that humans are not alone in the universe. In fact, we have neighbors who can see our little world here."

"That's right, Mr. Ambassador."

"And these neighbors not only have better telescopes than we do, they have better radios as well."

"Again, that's correct."

"That's a lot of knowledge from a supposedly secretive source." Klein studied his notes again. "And the signal that conveyed all of that knowledge to us, was sent by a transmitter far more powerful than anything we've ever built?"

As Bridget agreed once more, Matthews worried that Klein was overdoing it. The Third World delegations had already shown more discomfort with possible culture clashes and perceived inferiority than the physicist had thought possible.

"Thanks for keeping me clear on these points, Doctor." Klein took off and polished his glasses, the image of a harmless college don. "Some of my esteemed colleagues have raised a concern, and I am not unsympathetic, about the cost of the task force.

"I have reason to believe that these are not the only costs. If I could refer you for a moment to your 'day job,' would I be correct in my understanding that radio spectrum is a valuable resource? An economically precious resource?"

Bridget leaned forward with a renewed confidence. She (and the ambassador) had gotten it. "Very much so. For example, we had to disrupt the plans of a global satcom company to avoid interference on ET's channel." She had in mind NetSat.

"I see. Presumably our Lalande friends have to sacrifice the same frequency to communicate with us?"

"Yes."

Klein turned his attention to his fellow ambassadors. "I find that my perception of ET differs from some of my colleagues. For example, I feel that I know a lot about him. He's curious: he wants to know more about us. He's smart: he knows a few tricks we might like to learn. He's serious: whatever effort we've made to hear and understand his signal, it must be *far* smaller than the investment ET made to formulate such an elegant message, to reserve valuable radio spectrum just in case we answer, and to devote a transmitter the likes of which we have yet to build. We would know none of that if our neighbor had simply chosen not to tell us."

He tucked his notes—perfectly delivered, so far, thought Dean—back into his jacket. "It's said that money talks. ET has dedicated quite a lot of whatever he uses for money to this endeavor. I think he's entitled to have us hear him out.

"I predict," and here Klein paused

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dramatically, "that by the time we've finished the processing of ET's message, we'll have discovered a request for information from us." Matthews silently mouthed *his* prediction along with the ambassador.

"I think we all should keep an open mind about how, what, and when to answer ET. For surely, if we do not reply, it will be *his* committees deciding not to throw good money after bad."

He smiled once more at Bridget. "And then who can say what amazing knowledge we will have forfeited?"

CHAPTER 7

The steerers were disinvited from day three of the hearing, where COPUOS would decide the task force's fate. Bridget and Dean sought distraction at the Statue of Liberty. She had never seen it; he'd visited it at the age of eight.

"That is one handy connection you have with Alex Klein," she offered on the return ferry. It was the first violation of a tacit no-business policy.

"Oh?"

"I've been holding back, too. It appears you were right about ET requesting information." She paused as the ferry's horn blasted. "Although it's generally impractical to decode out of sequence, the analysts have scanned ahead in the message. They figured that a sneak preview might suggest in advance technical specialties we should add to staff."

"So what lies ahead?"

"The message gets more and more complex. Most of what's left looks like physics and electronics. Amid that technical detail, oddly, is a return to arithmetic. That's followed by a brief return to chemistry. The arithmetic and the chemical reactions both use a symbol we don't understand. Everyone assumes we'll know what it means once we read things in order. The puzzling thing is, that symbol doesn't appear earlier."

"Give me an example?"

"Sure. Call the undecoded symbol 'X.' The math is stuff like 2+3=X and 7-1=X. The chemistry starts as similarly basic chemical reactions, with a reactant missing, replaced by X. Then X shows up in a lot of hairy chemistry material."

A cloud blew over the sun, turning the harbor air instantly chilly. He was too deep in thought to notice. "You didn't pick 'X' at random. You're thinking of everyone's favorite algebra variable: X the unknown."

"My mind's been heading that way since the speech you put your ambassador up to."

"Okay, let's assume 'X' *is* something to be solved for. ET used trivial arithmetic problems to introduce the symbol. He used simple chemistry problems to generalize the concept beyond math. And then. . . ." He stopped, staring into space.

"And the remaining occurrences of X might just turn out to be ET's shopping list."

Matthews' cell phone chimed as the ferry docked. Chattering, jostling tourists almost drowned out Alex's news. COPUOS had narrowly approved task-force continuation: a 43-40 vote. Dean gave a thumbs-up to Bridget, now on her own phone.

The gesture was arguably too soon. Alex's next words were less upbeat. "Winning this round meant cashing in several favors owed the U.S. I expect Mbeke and his allies will try packing the committee with new Third World members before the next review. If that happens, I don't see where the votes would come from to authorize a reply."

Bridget's call was a summons for them both from Kim; they took a cab from the dock to the UN. One short hour after the vote, hundreds of Earth Firsters were already demonstrating in front of the UN building.

To Dean's surprise, Bridget excused herself when they got to the Undersec-

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retary-General's office. "Today's vote was unpleasantly close," said Kim, as the door closed behind Bridget. "We must do better next time."

Dean shrugged inwardly. Where was this going?

"Perhaps we need fresh thinking. The kind of insight that your ambassador showed yesterday . . . . with your input. Bridget also speaks highly of you." Kim smiled, "Joining the steering committee would be much more efficient than maneuvering us."

Matthews didn't protest the insinuation: there was adequate truth to it. Coming from a career politician and diplomat, the remark was probably meant as a compliment.

"Now assuming that you *will* join us, I suggest that you join a post-vote strategy session."

CHAPTER 8

It turned out that Matthews' prediction on the ferry had been only half right.

At his suggestion, the next steering committee meeting included a synopsis of the whole message. The head of the Analysis committee, Koji Matsumoto, gave the summary. Koji was an intense astrophysicist on loan from NASDA, the Japanese space agency. He looked surprisingly awake for someone teleconferencing from Tokyo, where it was 3:00 a.m.

Matsumoto uploaded a graphic. "This chart overviews the entire message and our progress in reading it. Message blocks flow from left to right and top to bottom. The 'look at me' pulses and earliest images are at the top left. As you know, ET marks each image with the dimensionality and size of the next image. This lets us separate the message into its parts, although many of the later blocks don't make sense yet."

Dean studied the graphic. In rough terms, he visualized the image in three segments. The first quarter was red, fading to orange. The middle half was yellow. The last fourth spanned the rest of the rainbow, in thin slices.

"The blocks we think are fully decoded appear in red. We have covered that material at earlier meetings. Orange shows blocks that are partially interpreted. We believe the yellow area that follows is, like the orange, progressively more advanced mathematics, physics, and chemistry."

Matsumoto sent a new image. "Here we see more detail about the end of the message. The thin green slice is only a few frames long: it is where ET introduces what we think is a question-mark symbol. The blue that follows is what Dean called the shopping list; we'll return to that. The indigo area seems to be electronic schematics. Violet, the final section, appears to derive units of measure, such as time intervals, from fundamental physical constants."

Another graphic appeared, its blue border suggesting that it came from the shopping-list portion of the message. Dean saw a chemical reaction in which the presumed question-mark character represented a catalyst. Beneath the reaction was a line of three other symbols.

Matsumoto went on. "Here is a typical frame from the shopping list. It certainly seems plausible that ET is asking if we can identify a catalyst for this chemical reaction. On the next line are the 'us' and 'them' symbols, Earth and ET, separated by something we didn't recognize at first: a vector symbol from the early physics tutorial. We think it is used here to show direction."

In short, the line read: "Earth to ET."

Flick. Another blue-bordered graphic appeared. It, too, showed a chemical reaction, seemingly for a fuel cell. A question mark again stood where a catalyst would be indicated. Beneath that were the us, to, and them symbols—but with one key difference: the direction of the vector was reversed.

"In addition to what Dean called ET's shopping list," said Matsumoto, "we

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think ET has sent us a catalogue."

From the Earth First chat room.

All_Politics_Is_Local: The $%^#!! UN is still moving toward a reply to ET. How can they be stopped?

Stop_World_Government: See your verbs, dude? Passive voice! UR the problem. What can *you* do?

All_Politics_Is_Local: I'll bite. What can I do?

Radical_Dude: Be in New York when COPUOS meets next. Earth First is organizing mass demonstrations, with support from around the world. If the UN doesn't change course, we'll show them that the Battle of Seattle was only a tea party. Earth's precious resources are for Earth!

All_Politics_Is_Local: I have been properly rebuked and reeducated. Earth First!

Radical_Dude: Amen to that!

Call it barter, which sounded primitive, or trading intellectual property, or *very* long-distance e-business. By any name, the task force had finally answered the question, "What does ET want?"

He wants, it would seem, to learn useful things from us.

Though something like this had been suspected for days, since Dean and Bridget's ferry ride, it was more persuasive in Matsumoto's concise briefing. Consensus quickly jelled on the interstellar trading scenario. Speculation swirled about how the system could work. More heat than light was being generated.

Matthews coughed for attention. "Koji, could you bring back your first chart?" The image Matthews had requested popped up. "I'm going to climb out on another limb.

"As we keep relearning, ET is very systematic. So why do electronics reappear after the shopping list and catalogue? Koji, might the indigo area be a new tutorial or trade goods?"

"We see no new symbols in the indigo region, so I would not think it is tutorial. We also found none of the 'us to them' or 'them to us' phrases, so I do not think indigo relates to trading."

"As I expected." Matthews pushed back his chair, feeling the need to pace. "One of the few things ET already knows about us is that the signals we send, or more accurately leak, are so weak he can barely hear us. That's pretty clear from the time-lapsed replay of what he's heard. Surely if ET had extracted any information from Earth's radio leakage, instead of just our dial tone, he'd have sent a bit of it back to let us know.

"ET's transmitter is far more powerful than anything on Earth, or it's capable of incredibly focused beamcasting, or both. So, another speculation. I bet that the indigo material, the electronics, is a transmitter design. There's no reason for ET to ask to trade until we learn to speak intelligibly."

"Perhaps I can complete the decoding," added Matsumoto. "If we grant Dean's speculation, a meaning might also be placed on the last portion. At a high level, as I said, the part of the message coded in violet derives units of measure. This appears to include time intervals and a radio frequency.

"If Dean is correct, the last part of the message may be telling us when and where ET will be listening for our reply."

CHAPTER 9

A side effect of Matthew's new assignment was more time spent in New York. The steering committee met often, with only the furthest-away members telecommuting. His house plants took it hard, but otherwise it worked well. In particular, it gave him the chance to better bond with the other steerers. His new routine of a morning jog with Vladimir Antinov was pure bonus.

Pounding along a Central Park track, Dean saved his breath for keeping up with the fanatically fit general, while An-

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tinov did the speaking. Each run brought a revelation and the always useful reminder that one learned more by listening than by talking.

Today Vladimir was pondering a new press release from Dean's former committee fellows. His perspective was always an eye-opener, as different from Dean's industrial viewpoint as Dean's was from the academics and bureaucrats who dominated the task force.

"Good technique, my friend, divide and conquer." The Russian didn't appear to be sweating. "Analyzing as much of the message at once as possible makes sense."

"In my world, we call it parallel processing."

"The labs back home say it is an interesting approach." He referred to what had indeed proven to be a transmitter design.

Dean considered, reminded of his favorite evasion. As in: this casserole is interesting. "More surprising than interesting." Pant, pant. "Curiously complex."

"You should think like a Russian." When the physicist made no reply, Antinov continued. "Consider *Mir*. I loved seeing the faces on your astronauts when they first came aboard. They were in shock about *Mir*. So primitive. So klugged."

"Kludged?"

"Yes, thanks. Kludged. Despite our kludging, or maybe because of it, USSR had a space station twelve years before one piece was launched for a NASA space station." He jogged in place at the crest of a hill while the huffing American caught up. "The best is the enemy of the good enough."

"My brain is not at its best when bouncing."

"You Americans believe advanced capability requires advanced technology. You think ET's solution must be simple and elegant." They zigged off the path to pass some mere power walkers, then zagged back on. "You never think of *Mir*."

"So." Matthews was out of breath. "You're. . . . saying. . . . brute force."

"Perhaps. Of course, I would not know an elegant radio design if it shot at me. I only suggest that you consider it."

"Food. . . . for thought."

"Only five kilometers. You would not survive a real run." Antinov pointed to a coffee shop. "Come, we'll get some real food."

"The University of California at Berkeley announced the discovery at the end of the ET message of a deadline for Earth's response. Dr. Enrique Ramirez, of the Department of Computer Science, stated that ET has requested that Earth begin its reply 97 days from today.

"A UN spokesman confirmed that its task force had been seeking an independent validation of a similar translation. The spokesman would not speculate what answer the task force might recommend, or even whether a response was under consideration."

—GlobalNet Evening News

With time running out before a pre-reply COPUOS review, and the authorization vote Alex Klein predicted the task force would lose, Matthews widened his search for ideas.

After hours of chat-room exploration and web surfing, Matthews encountered "A note on amplifiers in the Lalande 21185 transmitter design" by a Joachim Frisch. Dean clicked on the URL and started scanning. As an aura of professionalism emerged, his reading slowed down. Searching on the author, Dean found nine papers in refereed engineering journals, although the most recent was ten years old.

His second review was very slow and deliberate. He was reminded of, and thought deeply about, Vladimir Antinov's comments about *Mir*.

It was early evening in Frankfurt. Hoping that Herr Frisch was not out enjoying the Oktoberfest, Dean started to dial. *From the SETI Conspiracy chat room.*

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Suspect_Everyone: So now there's a pressing deadline to answer ET . . . . Who else smells a six-legged, bug-eyed rat?

42_is_true: How convenient! ET spies on us for 30+ years and we get a few months to reply. What's the rush?

Suspect_Everyone: The rush, my naive friend, is to stampede us. Remember that the UN already pushed through a treaty allowing only *them* to answer ET. The vote to reply will be one more pretense why we "need" world government.

Remember_Seattle: They've made a losing gamble. Once we delay them past the deadline, the whole pretense lapses. Join Earth First at the barricades in NYC.

CHAPTER 10

The stretch limo of the American UN mission was twenty minutes late in retrieving Matthews. Traffic crawled, snarled by picketing Earth Firsters. Despite the unruly crowds, Dean could have made faster progress on foot.

"Thanks for seeing me on such short notice. I appreciate your flexibility, since my calendar doesn't offer much."

"You're welcome, Mr. Ambassador. What can I do for you?"

"Please, we're alone. It's just Alex. I wanted to advise you of an issue in regard to your recent inquiry."

Matthews didn't speak diplomatese, but in his experience an issue was never a good thing.

ET's shopping list and catalogue, when decoded, had been much alike. All sixteen entries on the shopping list were related to chemical reactions and materials science. The catalogue hinted at fifteen catalysts and materials; the sixteenth entry promised a superior optical telescope design.

It was commonly interpreted that ET would swap any item from his catalogue for any item we supplied from his shopping list. The problem was with comparative skill levels: ET's wares and the new solutions he sought were both mostly unfamiliar to the task force's chemists and chemical engineers. Lots to ask for; nothing to trade.

ET's shopping list included catalysts for fuel cells. There had been a long-shot chance that the US national labs had related unpublished work. Alex's office had agreed to expedite a DoE query for Dean.

"First off, no luck with the national labs. I'm told, in fact, that the example ET used to define 'fuel cell' is potentially better than anything we have.

"On the other hand . . . . my good friend, the secretary of commerce, was contacted discretely by two key constituents, if you know what I mean. The corporations they represent may each have one of the catalysts sought by ET. The research is not yet ready for patent application."

Key constituents, presumably, were campaign contributors. "Will they share information with ET? Do they understand the impracticality of obtaining payment from him?"

They grabbed armrests as the limo braked suddenly. Three protesters in bug-eyed-monster masks with Devil's horns had darted in front of the vehicle. Their waving placards asked, "Do I look trustworthy?"

Klein grimaced at the street theater. "Barter is awkward, as is the delay. Sixteen years round-trip? That's not the real issue, however.

"Sending technology to ET means a turnover to the task force for encoding and transmission. Neither company trusts the UN to keep proprietary technology secret here on Earth.

"Federal purchase of the technology has been mentioned, but we're talking billions. A purchase probably couldn't happen in time, even if it were the right thing to do."

Matthews looked glumly out blackened, one-way limo glass. More and more demonstrators streamed past the trapped limo towards the UN. "Look at

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this crowd. Can they spell Luddite?"

The ambassador snapped shut his briefcase. "The major economic powers all *want* the ET technologies. We've been trying hard to freeze COPUOS membership until after the natural milestone of an authorization to reply. I expect to lose the procedural vote on that membership freeze today.

"We have nothing to trade, long odds of getting a reply authorized are about to get worse, and the clock is running out. Your Luddites are the least of our problems."

"I became interested in a report from the Analysis group. As they had determined, there are obvious subassemblies for signal modulation and amplification. There is an impressive design for focusing and steering a beam using a phased-array antenna, like we use for radars. It is elegant work."

Joachim Frisch tapped the printout spread across his dining-room table. The schematic was roughly two meters by three. It had been printed on letter-sized stationery and taped together. "And then we have *this* complicated mess."

Frisch was a frail, grey-haired gentleman of seventy-three years. He'd never fully recovered from a car crash two years earlier, and was wheelchair-bound. Until his retirement, he had been a customer-support engineer at the big German electronics firm, Siemens. He still did freelance consulting, troubleshooting others' designs and suggesting improvements.

"Forty years moving from customer to customer, application to application, builds a skill set. I thought that mastering yet one more design, even an alien one, would be easy. I've seen *many* radio circuits in my time."

Matthews nibbled on one of the biscuits set out by Frau Frisch. *Honigkuchen?* "Your web posting suggests that you had more success than the task force."

"Ah, but I cheated. I have a hobby to help." He rolled into the adjoining living room and opened a cabinet to reveal a rack-mounted set of ancient stereo components.

To a crisp, metronomelike performance of the Fifth Brandenburg Concerto, Matthews reconsidered his mental dating of the equipment. The sound quality was exquisite, at least as good as that of his own recently purchased stereo. The orange glow of vacuum tubes had clouded his judgement. "I admit it, I'm a transistor chauvinist. These tubes produce a better, truer sound. How long did this take to build?"

Frisch laughed. "I began in college and I'm not done. In these modern times I must make many of my own tubes. Later, if you wish, I will show you my workshop."

"So what do you find most interesting about ET's radio?"

"Our symbols for electronic components of course differ from ET's. We learned ET's symbols early in the message, in the physics tutorial. Do you agree?"

"I think so," said Matthews. "I am not an expert in that part of the message."

"ET drew a wet-cell battery and showed it with a new icon. This is how we know his symbol for a voltage source. He made an animation of electrons moving, and another symbol, and we know how he shows current.

"Then ET drew the simplest possible circuit: the voltage symbol in series with one new symbol. The drawing is above the most familiar of electrical equations."

Ohm's law, recalled Matthews: junior-high physics.

"Obviously, the new symbol is for a resistor," continued Frisch. "There is also a graph. It is not drawn as we would, but from context, it is recognizable: current versus voltage in the new device. The graph describes a resistor, so the plot is a straight line."

Matthews nodded. "We don't know how ET builds a resistor, but the circuit

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is so simple we were sure to recognize the new element. The real purpose of the chart was to introduce voltage/current plots, transfer functions."

"Indeed."

"And does ET use transfer-function graphs to describe all of his other circuit elements?"

Frisch smiled. "Exactly! Later in the message such graphs define many new electrical devices. They behave like diodes, capacitors, inductors, and other familiar parts."

"Leaving to us to decide how the component is actually constructed." Fascinating. "Almost any EE today, seeing a three-terminal amplifying device, would assume it was a transistor. He would consider the associated transfer function drawing as a cartoon and dismiss any subtle differences from what is expected of a transistor."

"And only a stubborn tube-loving fossil would consider that it could be a tube, a triode." Frisch once more tapped the tablecloth-sized printout. Despite his obvious excitement, the old EE seemed weary. "But the way ET built his very high-powered amplifier section. . . . it is not like a transistor design. Not like a solid-state design."

"We should take a break. Would you mind one more question first?"

"Please."

"For a large radio transmitter, are there reasons to prefer tube technology over solid state?"

"None." Frisch rubbed his temple pensively. "ET has many parallel antennas in his phased array, so this task could easily be done with transistors. I have given the matter serious thought."

That fit. There was plenty of stress among the engineers assigned to boosting the power of some Earth transmitters, just in case a reply was authorized, but Matthews had heard not one word of worry about integrated circuit inadequacies.

Mir, thought Matthews. Antinov's advice never to underestimate what could be accomplished using only basics and brute force. "Unless ET doesn't have solid state technology."

Transistors and integrated circuits had revolutionized Earth, had made such sweeping changes that no one had considered that the seemingly advanced ET might not have them.

How valuable to ET would transistors be?

"The streets of Manhattan were brought to a standstill today, in a limited demonstration of Earth First's resolve.

"Earth First has united the many communities committed to protecting our world's interests. Our voices include people of faith, supporters of national sovereignty, defenders of our planetary resources, and guardians against extraterrestrial duplicity. We come from every class, country, and continent.

"Members of COPUOS, disband the Lalande task force, or face our wrath."

—Earth First communique

Within minutes of leaving the Frisches' apartment, Matthews had phoned Bridget. Within the hour, she was booked on the next flight from Geneva. She brought with her Sven Olssen, the ITU analyst who had first recognized ET's radio-frequency replay.

They began the next day with a whirlwind tour of the old city's medieval cathedral, since Frau Frisch had asked Matthews to delay his return until late morning. Her husband had been exhausted by the excitement.

"So," said Herr Frisch, "you return with friends today. These ideas of mine may have some merit."

Bridget laid a hand on the German's forearm. "Very much so. Your insights are most helpful. We appreciate your help."

"I wish I had insights to offer for the entire design." Frisch pointed at the alien schematic, still draped across the dining room table. "This whole section continues to elude me."

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Matthews laughed ruefully. "And an entire UN task force."

"Well, as I'm sure everyone has seen, this section provides input to the focusing and aiming circuits that drive the phased array. If so, some of this strange area generates direction information. Parts seem to do signal modulation and frequency shifting. Mostly we see what appear to be control loops. What and how they control I do not understand. It is so complex, loop within loop within loop."

They sat staring at the schematic. After awhile, Sven said, "If this were software, I'd call it spaghetti code. Everything is intertwined."

"While we're admitting to odd associations, I can top that." Bridget traced a circuit loop. "I'm reminded of something far more venerable. Maybe it was seeing the old cathedral this morning, but loops within loops bring to mind wheels within wheels. Pre-Copernican astronomy: deferents, epicycles, and equants."

Matthews' mind turned neither to software nor Ptolemaic astronomy. Something in the schematic, or in the comments about the design, reminded him in some way of challenges he'd faced *before* the task force.

That was when the metaphorical light bulb of enlightenment switched on.

CHAPTER 11

With only twenty days remaining until ET's reply window opened, COPUOS scheduled a task-force review to decide whether and how to respond. Rampaging Earth First protesters delayed the session's start by a day.

The USG summarized the task force's progress since the last COPUOS review. Completion of reading ET's message. An overview of the catalogue and shopping list. Specific reply windows proposed by ET, the first only nineteen days away—the opportunity after that, two years away. The immense benefits of obtaining ET's offered technologies. Earth's unfortunate lack of answers to ET's questions. The race to enhance Earth's largest transmitters so that ET could detect a signal and not just the carrier wave.

Then it was Matthews' turn.

"Many have expressed surprise, and some disappointment, that ET's message is commercial in nature. That approach has come to make sense to me. Our task force has not been an inexpensive undertaking. Radio telescopes are not inexpensive instruments. Adapting transmitters for interstellar use, sacrificing the use of spectrum. . . . these are all very real costs. Governments have historically found SETI a hard investment to justify. Dialogue with another star, however intellectually stimulating, can quickly come to seem less worthy of financial support than today's natural disaster or international incident."

Emotionless faces looked back at Matthews, diplomats all skilled at internalizing their reactions.

"Can humanity maintain a purely intellectual conversation in which answers to our questions will come, at best, after a sixteen-year delay? Will we maintain financial support for such a dialogue? I don't presume to speak for Earth; that is the responsibility first of this committee, and, based on your recommendation, for the entire United Nations. ET, however, has reached a conclusion for *his* society: communications with Earth are to be self-supporting.

"So ET constrained our decision: there must be value to him in our reply. Perhaps we can also learn about each other's cultures, but only if our relationship works economically.

"Here is the crux of our problem. ET has more sensitive radio receivers than we, more powerful transmitters, better telescopes. His knowledge exceeds ours in the areas, chemistry and materials science, in which he solicits our contributions. While there may be exceptions, potentially tradeworthy technologies in

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our most advanced laboratories, we are entangled in ownership issues here on Earth.

"The question becomes, simply: what do we have to trade?"

Ambassador Smythe of Belize cleared her throat. "It is a rather delicious irony that the developed world's knowledge is not commercial."

Matthews ignored the barb. "We've all felt hampered throughout this investigation by how little we know about ET. Well, ET knew less about us when he sent his message than we now know about him. Recognizing how ET jumped to conclusions about Earth may help us be more realistic about him.

"Effectively, ET could hear us whispering, but not make out anything we said. We presume ET sent us a transmitter design because he inferred from our weak transmissions that Earth couldn't talk any louder. That's incorrect. He offers us his sophisticated chemistry, and apparently feels, with no basis that we can see, that our chemistry must be comparably advanced. That is also wrong.

"The transmitter design is the single largest part of the message. Analysis of the design has been enlightening. It is a more powerful transmitter than humans have cared to build, but we *could* build a transmitter that powerful if we so chose. The undersecretary-general has explained how we are working to do just that. The interesting fact about ET's radio design is not its power, but rather something it took a while to recognize.

"It appears that Earth's electronics technology is *far* superior to ET's."

"Rioting Earth First demonstrators, unsuccessful at preventing the COPUOS hearing for a second day, have shut down areas of Manhattan up to two miles from the UN. Arrests now exceed two hundred. Sympathy protests are causing lesser disruptions in London, Canberra, Tokyo, Berlin, and Paris.

"Undeterred by but surely not unaware of the violence, the Lalande task force and the committee that oversees it continue to debate whether Earth will reply to ET."

—AP World News

The USG called a ten-minute break after Dean's revelation. Coordinating diplomats was like herding cats: thirty minutes later, the head count had only crept back to a quorum.

"I worked at a satcom company before joining the task force, and that background provided a useful insight.

"To be pocket-sized, satellite-capable phones must avoid big batteries and antennas. We put the satellites in low Earth orbit to minimize power requirements for the phones. In these orbits, satellites constantly move in and out of sight. It takes a lot of software to sort out which satellite should handle a particular call, and when to hand off a call to another satellite. Meanwhile, the Earth rotates under the satellites, bringing different ground stations into play."

"Yes, yes, Dr. Matthews." Ambassador Smythe stood in the doorway, back from her extended break. "I'm sure your former employer appreciates the advertisement. It isn't clear that ET would be impressed."

Dean decided to overlook both gibes. "Because satellites move along their orbits and ground stations rotate with the Earth, there are continuously varying Doppler shifts over various links. The software must adjust.

"You'll recall that ET's signal maintained a constant wavelength. Achieving that constancy took correction in real time for the relative motion of ET's star and our sun, for the orbital motion of our planets, and for the rotation of our planets. The calculations resemble those with which I am familiar from the design of satellite constellations.

"Our analysts have closely studied ET's transmitter design. Two observations surprised them. First, ET's electronics are based not on transistors and

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integrated circuits, but on vacuum tubes. That was astonishing enough. The second conclusion was more amazing. ET does not employ digital computing."

Scattered whispering had erupted in the gallery at the mention of vacuum tubes; the comment about computing elicited even less seemly murmuring. The chairman glared at the small audience. "If necessary, I will clear the room of all staff and invited guests." He motioned at Matthews to continue.

"I reviewed my background only to make a point: Doppler correction is familiar to me. The geometry can be messy, but the correction is easily programmed into a standard digital computer. ET has a distinct analog control loop for each component of motion: his planet's orbit, his planet's rotation, Earth's rotation, and so on." More precisely, and of doubtful interest to the diplomats, ET's transmitter employed coupled feedforward servo controls.

"ET's system works, or we would never have heard him. Still, by our standards his approach is *extremely* cumbersome. Each correction factor is provided by a physically separate circuit, involving many vacuum tubes. Tubes are inherently unreliable devices, compared to transistors. That makes his circuits prone to component failures."

Crowd noise and the sound of gunfire—with rubber bullets, Dean silently hoped—repeatedly punctuated the briefing. Scowls began exceeding sympathetic expressions as the din rose repeatedly. Had Earth First overplayed its hand?

He pushed on. "ET's most advanced technologies appear to be chemistry and materials science. In these areas ET clearly exceeds our knowledge. But ET does not know what he does not know: solid-state physics. He probably never seriously investigated digital computing: our pretransistor computers were unreliable novelties, room-sized monstrosities with less computing capability than my wrist watch. Digital computing simply isn't practical without solid-state devices."

Once more the roar of angry protesters made speaking difficult. The supposedly multicultural demonstration seemed to have found one voice: obstructionism. Resistance to change. An inarticulate remembrance of his time on the Media committee nagged at his subconscious.

Dean took a deep breath. "At this time, I'd like to introduce the task force's recommendation. We *should* respond to the Lalande message, starting transmission in seventeen days as per ET's request. We should order from ET's catalogue.

"For prepayment, we propose to ignore ET's shopping list. We would instead send introductory instruction in computing and the design of some simple solid-state devices. It need not include anything proprietary. Our accompanying catalogue will be for more advanced device designs and digital algorithms.

"We would be surprised indeed if ET failed to find these new technologies far more attractive than anything he has requested."

In a logical world, the presentation was complete. In this world, the fun had only begun. As Roberto Ramos, the Chilean ambassador, was being recognized, Dean spotted Alex Klein's prearranged gesture identifying a planted question.

"Dr. Matthews. A point of clarification, please. Is the task force proposing that Earth's trade goods be elementary computing and electronics techniques?"

"That's correct, Ambassador."

"Technology we all . . . " and here the ambassador's arm sweep encompassed the many nations comprising COPUOS, " . . . have mastered and moved on from."

"Yes. ET's science appears not to have gone in those directions.

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"And in return for our decades-old technology we can expect to receive advanced chemical knowledge. In effect we get something for nothing." Ramos thumped the table. Around him, many ambassadorial heads were nodding. "How can we lose?"

"Who are 'we' that cannot lose?" The question came from the task force's nemesis, Ambassador Smythe of Belize. "Who obtains this advanced chemistry?"

"If I may?" It was Khaldun ibn-Saud, ambassador and crown prince of Saudi Arabia (and, Matthews suspected, another Klein ally). "All of our universities have listened to ET. When he responds, all will do so again. We shall *all* get the new technology."

Another outburst from the street interrupted the discussion. Li Zhou Huang, the Chinese ambassador, narrowed his eyes. Despite its extreme understatement, the facial expression left no doubt how Li felt about the disorder. Of course, Dean remembered, his government still rationalized the Tiananmen Square massacre. Talk about cultural differences.

The physicist's mental alarm triggered again. Putting his trust in his subconscious, he gave less than his full attention to the debate. The ambassadors were talking to each other now, rather than questioning him, anyway. Cultural differences. Cultural sensitivities.

As controversy raged, the message decoding remained unchallenged. The potential benefit of the proposed swap was uncontested. The subliminal text of Matthews' briefing, that ET would get technology inferior to what the less prosperous countries had already mastered, seemed to have converted a few ambassadors. That was one cultural sensitivity addressed. . . .

What *was* his subconscious poking at?

A steady stream of objections, orchestrated by Ambassador Smythe, pressed what seemed to be the last counterargument to a reply. Who is this ET? Why is he so secretive? What are his motives? Stripped of all pretense, the obstructionist case was simple xenophobia.

French-accented English in Dean's earpiece presented the objections of Chad. Some combination of the female translator's accent and the booming bass voice of Chad's ambassador recalled the leader of the Media & Education committee. "Our role is to package and control the Lalande information," Paul Ricard had said at the kickoff, "while respecting various cultural sensitivities."

Dean had focused that day on the impracticality of *controlling* ET's information. What about the *packaging* of that information? He'd sat through dispute after droning committee dispute about the optimal multicultural spinning of prospective announcements. What had he learned?

Swelling chants of, "Hey, Hey. Ho, Ho. COP-U-OS has got to go!" began again to drown out the debate. Sirens erupted. Li Zhou Huang's eyes narrowed once more, his hostility towards the crowd's coercion evident. Earth First had been wise to omit China from its planned disturbances.

What did ET know about Earth's cultures? Almost certainly, nothing. Ditto for any sensitivities that knowledge of ET's culture might arouse on Earth.

"ET hang up! ET hang up!"

Few things are as satisfying as the realization of a previously unrecognized assumption. When the outside chaos momentarily ebbed, Dean seized the floor. "The concerns now being expressed may rest on a misapprehension."

"And what is that?" asked Ambassador Smythe icily.

"That ET is being secretive." He spread his arms wide. "Many cultural perspectives are evident in this room. Despite that, our talk of 'ET' suggests we may have fallen into the error of positing a single alien culture.

"Imagine an ET conference preceding their transmission. Perhaps they too have many cultures, developed over mil-

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lennia. Their national representatives argue over how to introduce themselves to their newfound neighbors: us.

"Will they present all of their cultures, or the supposed important ones, or only their cross-cultural commonalities? Will each society describe itself, or must all groups agree to every description? Will their entire history be an open book, or should embarrassing episodes be withheld? What is sent when two nations, one perhaps an ex-colony of the other, or former military adversaries, disagree about events? Will explanations be made about contradictory religions or systems of economics? How might our society, or societies, react to theirs?

"ET took more than thirty years to contact Earth after detecting humanity's presence. We have all wondered why." Dean slowly and deliberately made eye contact with each ambassador. "Perhaps the ETs needed that long to agree upon the one mutually acceptable description of their cultures. . . .

"Silence."

When Li Zhou Huang and Alex Klein simultaneously smiled, Dean knew that he, the task force, and humanity had won.

EPILOGUE

The auditorium was packed in flagrant disregard for the fire code. More people filled the hallway. Matthews recognized task force members, COPUOS ambassadors, talking heads from the networks. People kept glancing at their watches. Twenty-one minutes to start of transmission, and counting.

Dean wriggled through the crowd to join Bridget, who looked as exhausted as he felt. Fair enough: refining and encoding Earth's reply, then checking and double-checking it, had taken 'round-the-clock efforts for two weeks. The Reply committee had borne the brunt of it—the final tweaks to the message had been made just that morning, but almost everyone on the task force had felt the crunch.

"I find myself envying ET. Discovering unexpected courses in quantum mechanics and computing. Following our recipes to build their first transistors and solar cells." She gestured with a meatball on a toothpick. "And *then* he'll read our catalogue."

"So you think he may be interested in processes for making integrated circuits? Or schematics for the old PC in my den closet?"

"Could be," she grinned. "Really, it's a brilliant solution. Trade our common knowledge, that no one can object to parting with, for their expertise."

"And since we'll post our message to the Web, everyone who cares gets a sneak preview of our order. That's at least sixteen years to figure out ET's technology or to decide to exit a business that could be made obsolete."

"Your attention, everyone," called the amplified voice of Kim Chun Ku. A wave of shushes broke out. "Please be seated."

On stage, large-screen TVs showed the great parabolic antenna at the Jodrell Bank radio observatory (now also an interstellar transmission station), the nearby control room, and a slaved copy of the main console display bearing only a decrementing counter.

The antenna was prepositioned, its motion as it tracked Lalande 21185 too slow to be visible. The control room had been vacated by all but a few technicians, the USG, and Sherman Xu. As the counter reached sixty seconds, Kim whispered something to the man who had started it all. The crowd cheered as Xu took his seat at the console.

At zero, Xu tapped the enter key. To thunderous applause, the text of Earth's response began scrolling down a monitor in the auditorium. Dean and Bridget embraced, and were far from the only people exchanging hugs, kisses, and backslaps.

The more important version of the message took the first step of its jour-

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ney: an uplink to a geosat over the Atlantic for relay to Jodrell Bank in the UK. Jodrell Bank would start Earth's beamcast: responsibility would be handed off from transmitter to transmitter as the world turned. The eighteen-hour message would repeat continuously for the thirty days ET had said he'd be listening.

The USG entered the auditorium to thank everyone for their contributions. He kept his remarks brief, knowing them to be anticlimactic. The room emptied slowly, everyone too wound up to leave but for the first time in months lacking a clear purpose. Party noises from down the hall were subdued.

Dean and Bridget found themselves alone in an otherwise empty auditorium. "Yes, I envy ET," repeated Bridget. "He has only eight years to wait. We've got to endure twice that."

"We actually have plenty to keep us busy."

Perhaps eyes actually could twinkle—he was emitting some good vibe.

"Okay, Dean. What *haven't* you told me?"

"Remember ET going off-line a while back?"

"Sure. Didn't we decide his planet was going behind his sun? Too much interference?"

"That 'explanation' was purely speculative, since we can't see his planet."

She tipped her head in puzzlement. "What *are* you saying?"

"There's a small matter I've kept to myself since we cracked ET's transmitter design. Remember the beam-steering and Doppler-correction logic? That circuitry is implicitly a model of his planet's movement and ours. I took the liberty of programming the model onto my laptop."

"So *is* our speculation plausible? Might ET have stopped sending because his orbit meant his sun would be in the way?"

"Not even close. ET had another reason for stopping his transmission. My guess is that he had another use for his big transmitter." The smile Dean had been hiding burst forth, an ear-to-ear grin.

"Now that we've built ourselves a phone, it appears we *might* have other neighbors to introduce ourselves to." ■

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In Green's Jungles, Gene Wolfe, TOR, $24.95, 384 pp. (ISBN: 0-312-87315-8).

The Fifth Elephant, Terry Pratchett, Harper, $24, 321 pp. (ISBN: 0-06-105157-8).

Tangled up in Blue, Joan D. Vinge, TOR, $23.95, 237 pp. (ISBN: 0-312-87196-1).

The Jazz, Melissa Scott, TOR, $23.95, 316 pp. (ISBN: 0-312-86802-2).

Callahan's Key, Spider Robinson, Bantam, $23.95, 336 pp. (ISBN: 0-553-11163-9).

Radio's Captain Midnight: The Wartime Biography, Stephen A. Kallis, Jr., Mc Farland, $28.50, 262 pp. (ISBN: 0-7864-0621-6).

ANTHOLOGIES

Moon Dogs, Michael Swanwick, NESFA Press (P. O. Box 809, Framingham, MA 01701), $25 ($36 slipcased), 413 pp. (ISBN: 1-886778-22-1).

Knights of Madness, Peter Haining, ed., Ace, $6.50, 318 + xiv pp. (ISBN: 0-441-00682-5).

Skylife: Space Habitats in Story and Science, Gregory Benford and George Ze browski, eds., Harcourt, $28, 355 + xii pp. (ISBN: 0-15-100292-4).

Aurora Awards, Edo van Belkom, ed., Quarry Press (P. O. Box 1061, Kingston, On tario, Canada K7L 4Y5), $16.95 (from Barnes & Noble, bn.com), 220 pp. (ISBN: 1-55082-264-0).

Starlight 2, Patrick Nielsen Hayden, ed., TOR, $24.95, 318 pp. (ISBN: 0-312-86184-2).

E-BOOKS

The Beginnings of Forever, A. L. Sirois, Clocktower Fiction (http://www.clock towerfiction.com), $5 (discounted to $4)(ISBN: 0-7433-0004-1).

It is in the nature of things that as children and protégés grow up, they internalize their parents and mentors. They may deliberately model themselves on or imitate or they may try very hard *not* to be like their predecessors. But there often comes a day—they look in the mirror, or a friend says something—when they realize that they are for good or ill a reflection of someone from their past. And then they deny it, perhaps because they feel they could not possibly be that good.

Some writers might take that basic idea and write a very specific embodiment called, say, *The Man Who Reflected Himself*. Gene Wolfe is more subtle, indirect, and complex. In the "Book of the Long Sun" quartet, he portrayed a generation ship, a hollowed-out asteroid, centuries into its voyage. Its inhabitants had little idea of the true nature of their "Whorl," and the systems that were intended to function until landing had degenerated. The major character was Silk, a sort of monk who—watched by the young and worshipful Horn, narrator of the tale—rose to become a leader and set the Whorl's people back on the track to their destiny. In due time, they left the Whorl and landed on the hospitable world of Blue. But Silk stayed behind.

The "Book of the Short Sun" trilogy began with *On Blue's Waters* (reviewed here last March). Horn, urged by dignitaries from the colonial town of New Viron, set out to seek Silk. But he was sidetracked to the hell that is Green, Blue's neighbor. He never achieved his goal, and his narration was a masterpiece of memory and the present and allusion to offstage events, including whatever took place on Green.

Whatever, it seemed clear that he had survived hell and returned to Blue. Ex-

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cept . . . Wolfe's sequel, **In Green's Jungles**, picks up where the last book left off. Horn is still fleeing the war that ended his reign as rajan of Gaon, still remembering the erstwhile natives of Blue, still dealing with the vampiric inhumi, still relating past adventures on Green in the interstices of an intensely interesting present as advisor to the chief of a city state threatened by a bellicose neighbor. And in those past adventures, he says, he died.

Then what's he doing here? Apparently, as he lay dying on Green, his spirit was transported back to the Whorl and inserted into another's head. Now, on Blue, he is not recognized by people who knew the old Horn—including his own son Hide. And he is often mistaken for Silk, his old mentor and model. He is even credited with a wisdom and compassion quite worthy of Silk.

No way! He couldn't possibly be that good!

But he isn't just Horn anymore.

But Wolfe is definitely Wolfe. Subtle and tricky and enormously readable. An ornament in the crown of science fiction. And never, never, never to be passed up.

Get thee to a bookstore.

What can one say about Terry Pratchett and his two dozen Discworld novels beyond, "Here's another! Have fun!"

I'll try. For those who have come in late, the Discworld series is an insane success in England and it does pretty well here as well. The premise is a flat world that rests on the backs of four elephants that stand on a giant turtle. Magic works. Death is a boney character that tries very hard to do a decent job. Luggage has legs. Dwarves, vampires, werewolves, trolls, and gnomes throng the streets and even serve on the local police force—the City Watch of Ankh-Morpork. The tone is irreverent in the extreme.

And there was once upon a time, says the tale, a fifth elephant. It fell from the sky, flailing and trumpeting, and struck the ground in what is now the land of Uberwald, where the dwarves now extract the long-dead pachyderm's fossilized fat from the lucrative mines of the Schmaltzberg.

And if that's enough to make you giggle, brace yourself. You're still in Chapter 1 of **The Fifth Elephant**. You have yet to learn of the impending coronation of the Low King of the dwarves, the conspiracy of werewolf stormtroopers to take over the joint, the theft of the Scone of Stone (on which the Low king must be seated for the coronation), the designation of Commander Vimes of the City Watch as Lord Vimes so he can be the city's ambassador to the coronation, the introduction of the clamp onto the city's streets to combat illicit parking by wagons, trolls, and opera houses, and a great deal more.

Have fun!

Joan Vinge has done a great deal of very interesting work in this genre, but she is best known for the series she began twenty years ago with *The Snow Queen*, concerning the world of Tiamat, whose binary star orbits a black-hole star-gate in such a way that it is reachable by the humans of the Hegemony only for 150 years out of 250. During these 150 years, Tiamat is dominated by a technophilic subculture, the Winters, who sell an immortality elixir drawn from the blood of sea beasts, the mers. During the remaining 100 years, the rustic Summers rule, worshipping Our Lady the Sea, holding the mers inviolate and trashing the technology accumulated by the Winters. You and I now know that the mers are a remnant of the Old Empire, as is the city of Carbuncle where the Winter queen, Arienrhod, presides over her own people and the Hegemony citizens who crave the elixir and tries to build sufficient power to maintain a technological culture through the interval of noncontact. The Hegemony, of course, wishes to restrict

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access to technology, for the Summer antipathy to technology means that when the Winters' time comes again and the interstellars return, the Winters are suitably primitive and exploitable.

This is the backdrop for Vinge's latest, **Tangled up in Blue**. The Blues are the cops who must enforce the technology-import regulations but are nevertheless hamstrung by a corrupt system. Some, such as Nyx LaisTree and his fellows, have turned vigilante; periodically they raid warehouses and destroy the contraband. Their superiors, including a young and priggish BZ Gundhalinu (familiar from other books in the series), do not approve.

One night, a raid goes sour. The vigilantes walk into a firestorm. Tree is the sole survivor, and he remembers that the people shooting at him were cops. Gundhalinu walks in, is sickened by the carnage, and gets a glimpse of a strange bit of Old Empire technology. And soon both Tree and Gundhalinu are invalided off active duty, each craving answers, each pursuing them in their own way, each growing increasingly suspicious of the party line.

Fortunately, Tree is enamoured of Devony Seaward, a prostitute with an Old Empire gadget that lets her change her form to fit any man's dearest dream. She is a spy for the queen, but she falls for Tree in return, and soon all three are hot on the trail.

And if the skein of plots within plots, the war of secret societies and chaos versus order, proves confusing at times, the foreground is well occupied by pain and romance, mystery and slaughter. This one will not disappoint Vinge's many fans, and it should awaken new interest in her older titles.

Melissa Scott has become a reliable name. Whatever she writes is bound to be a good read, nicely paced, peopled with likable characters, and equipped with a point. Her latest, **The Jazz**, is no exception: It says life ain't fair but it oughta be, and SOBs should get their just deserts. Meet Seth Halford, a teen known online as Keyz. He's a fan of "the jazz," a media art form constructed of image, innuendo, and rumor, strengthened by truth and expectation, fortified by "back-tech" or suitably manufactured photos and clips. It isn't unknown to us today—we call it spin, hype, or just plain BS and it's exercised in Hollywood, Washington, and Lantana, Florida (home of the *National Enquirer*)—but we don't call it art. Perhaps we should, for it certainly demands as much creativity and command of creative tools as does writing fiction.

Be that as it may, Keyz isn't just a fan. He's also a wannabe who has been using the computer in his room to create jazz scenarios and send them in to a major jazz site, Testify. He hasn't been having much luck, but now he's hacked into the major studio, RCD, that employs his parents. There he found and swiped a helpful program called Orpha-Toto. Testify, liking his new effort, pairs him up with Tin Lizzy, back-tech expert, to put the final touches on the package. And when Keyz's jazz goes online . . . Well, people like it, but the stuff really hits the fan.

RCD's head, Gerretty, is a major SOB. In a previous run-in with Tin Lizzy, he forced her to do time for what was really a minor crime. He treats hackers into RCD's computers the same way, and the media are so strong in this future that they have their own police forces, just as if they were cities. The hunt is on, and Keyz is running. Tin Lizzy takes him under her wing, and now they're both running.

And if the fuss seems extreme even for an SOB like Gerretty, Orpha-Toto is a very special program. It's the foundation stone of Gerretty's personal empire, and he has no intention of sharing it with anyone at all, much less some thieving kid.

Fortunately, Tin Lizzy has friends. She's also a master of the jazz, and in the

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end that's what saves everyone's bacon and dishes up just deserts.

Not that Keyz gets off scot free. Hacking's a crime, he knew it when he did it, Scott knows it too, and she tells the reader in no uncertain terms that the kid deserves punishment. But he doesn't deserve what Gerretty had in mind.

Spider Robinson has written a number of interesting, provocative novels, but it's the rollickin' good times of the Callahan's Bar series that seems to have captivated the fans. They've demanded book after book about Callahan's home away from home for the misfits and the weird, his wife's class A brothel, their wild punning contests, and their assorted adventures in world-saving, and Spider has obliged, even after Callahan had to leave to save other worlds and Sally closed her brothel.

One of Callahan's patrons, Jake Stonebender, tried to revive the Bar, but that lasted barely long enough for him to become the father of hypergenius (thanks to an internalized AI) Erin. The Bar is dead, the patrons are scattered far and wide, and Jake is pretty glum as **Callahan's Key** opens. But look! Here comes the immortal Nikky Tesla with word that the universe is about to end unless Jake Does Something. And here's a suitcase full of cash to Do It with.

So. Summon the troops. Announce a move to Key West (a place Spider rather likes). Gather up a fleet of retired school buses. And hit the road, arriving just in time to watch a Shuttle launch and find a nice location for the Bar before taking a good hard look at the problem and figuring out the only way—outrageous though it be—to ward off the ultimate catastrophe.

Speaking of which, the cover bears a nice likeness of Robert A. Heinlein's Cat Who Walks Through Walls, a talent that is crucial to the finale.

Good fun, good read, a surfeit of puns (of course), and seasoned with a sprinkle of quotations from the worthy J. Danforth Quayle, the Great Republican No-Brainer.

Once upon a time, Radio—all by itself—was Big Media. Television existed (it was invented in the 1920s) but it hadn't gone commercial and invaded every American living room. That was Radio's niche, and it filled it with a box the size of a TV set and a repertoire of programs that one might recognize today as TV without the pictures. Unless one insisted that TV was just Radio with pictures.

Whatever. Those programs included sit-coms and game shows, westerns and mysteries, romances and—yes, kiddies—even science fiction. It's almost all gone now, alas, surviving only as reels of tape in collectors' catalogs. Yet some of those old shows did make the transition to TV. One was "Captain Midnight," which I recall from the fifties as starring a hero who dashed off to scenes of crisis with the aid of a backpack rocket; he wore a helmet that looked for all the world like a rocket nosecone.

The pre-TV Captain Midnight was an aviator. Beginning in 1938 and continuing until after World War II, he flew numerous secret missions, fought criminal masterminds such as Ivan Shark, and did his best to save the free world with the latest, hottest tech while hooking thousands of kids on secret decoder badges and Ovaltine.

Both Captains are now no more than memories, but Stephen A. Kallis, Jr., is trying to change that with **Radio's Captain Midnight: The Wartime Biography**. He's working in the tradition of the biographers of Sherlock Holmes, Nero Wolfe, Tarzan, and Doc Savage. In the process, he has created a fascinating memento of the past that really should be marketed with a CD loaded with recordings of the original radio broadcasts.

ANTHOLOGIES

Every February, the New England Science Fiction Association holds a shindig

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in Framingham, MA. This is Boskone, whose name commemorates the villains of E. E. "Doc" Smith's seminal epic. This year the guest of honor was Michael Swanwick, and the occasion was commemorated with a collection, *Moon Dogs*. Here you will find enough of a sampling of Swanwick's shorter work—including the novella *Griffin's Egg*, reviewed here in June 1992—to see why he deserves to be honored. The title story—appearing in this volume for the first time—is a deft retelling of the myth of Diana the huntress, on whom no man must gaze when she emerges from her woodland bath.

Swanwick is a man of immense talent. Not only has he won the Hugo, Nebula, World Fantasy, and Theodore Sturgeon awards, but he has shown himself in posthumous collaborations with Avram Davidson such a master of style and voice that no seams are visible to demark his contribution.

He is also a classic in his own right. As he relates in the essays here, he began his writing career as a struggling, starving artist of very traditional sort. He lived in a garret, lost weight, sold his blood, the whole nine yards. We can be very happy he survived the experience.

Britisher Peter Haining has edited two anthologies of humorous science fiction and fantasy, *The Wizards of Odd* and *The Flying Sorcerers*. With **Knights of Madness**, he proves that good things as well as bad come in threes and, like Gaul, can be divided into three as well. *Knights* has sections devoted to tales of the absurd, mixed-up history, and crimes gang agley. The contributors include such familiar SF&F names as Ray Bradbury, Terry Pratchett, Philip K. Dick, Peter S. Beagle, Gene Wolfe, and Robert Bloch. You will also find Mark Twain ("Medieval Romance"), G. K. Chesterton ("The Angry Street"), Orson Welles ("Fifi and the Chilean Truffle"), Peter Sellers ("The Wastrel"), L. Frank Baum ("The Suicide of Kiaros"), A. A. Milne ("The Rape of the Sherlock"), James Thurber ("The White Rabbit Caper"), and more.

A delicious reminder that writers know how to have fun—and therefore so do their readers.

George Zebrowski has been concerned since he started writing SF with what Dandridge Cole called "macrolife," meaning mobile worlds "independent of planetary circumstances." He's hardly been alone, for dreamers such as Gerard K. O'Neill were pushing the idea of space habitats in the seventies and science fiction writers have set hundred of stories in such places, with James Blish's "Cities in Flight" series being a memorable example from the fifties.

Gregory Benford and Zebrowski have captured the history of this visionary idea in **Skylife: Space Habitats in Story and Science**. You will find here a background essay, an Asimov article on the subject, an excerpt from Zebrowski's 1979 *Macrolife*, a Benford *Analog* story ("Redeemer"), and stories by Blish, Joan Vinge, Greg Bear, David Brin, Larry Niven, Arthur C. Clarke, and more, including two brand new tales, Stephen Baxter's "Open Loops" and Paul J. McAuley's "Reef."

Not surprisingly, fully half the reprints originally appeared in this magazine.

Edo van Belkom has assembled an anthology of Class A Canadian SF in **Aurora Awards**, featuring eleven stories by Candas Jane Dorsey, Eileen Kernaghan, Robert J. Sawyer, and Robert Charles Wilson, among others.

Most of the stories are drawn from the last decade, when the amount of Canadian SF became significant. The Aurora was first awarded in 1980, but from van Belkom's account, it was initially often a struggle to find stories worthy of the honor. It isn't anymore, and this book proves it.

Patrick Nielsen Hayden offers you

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Starlight 2, an anthology of original stories staring Robert Charles Wilson, Martha Soukup, Ellen Kushner, Esther Friesner, and nine more. Worth a look.

E-BOOKS

The Internet is roaring full steam into the future, and it's hauling the publishing industry with it. Electronic rights are more and more something to fight over in contract negotiations, and many writers are finding electronic publishers instead of traditional paper publishers. Many of those writers are not worth much attention—a web site can be no more than a high-tech version of a mimeograph machine in the back bedroom—but some are. In fact some are among the biggest names you can imagine. Even Stephen King tried his hand at it last spring, with *Riding the Bullet.*

And here's A. L. Sirois, who has appeared in the major magazines but is more familiar to habitués of the small press. His collection, **The Beginnings of Forever**, delivers a quite readable dozen helpings from a deftly wry imagination.

His on-line publisher also has available three novels, *The Generals of October* (suspense thriller, $6 discounted to $4.80), *Blood Relations* (SF, $5/$4), and *Blind Ambitions* (SF, $5/$4). The latter two novels, with three of the stories in *Beginnings* ("War Baby," "Girl Talk," and "The Mechanisms of Dawn"), are part of a 10,000 year future history project.

IN TIMES TO COME

Jack Williamson leads off our December issue with "The Ultimate Earth," a new novella envisioning a far future in which most of humanity has been forced off Earth and some are trying to return. It gives new meaning to the phrase "You can never go home"; it seems there are at least two big reasons for that. And even a future in which human powers are greatly expanded does not imply a lack of problems—it seems that difficulties grow right along with our ability to deal with them.

"The Ultimate Earth" is, in a sense, the first part of a "quasi-serial." Jack will also have a novelette in our January issue which looks farther down that same sweeping future. But the two stories are so widely separated in time, and told in such a self-contained way, that you can understand and enjoy either entirely on it's own merits. And they represent what is, as far as I know, a unique accomplishment: this pair of stories will mark the *eighth* decade in which Jack Williamson has appeared in *Astounding/Analog*!

Our December issue will also contain the usual smorgasbord of additional fiction and fact, including a new "Draco Tavern" story by Larry Niven, something for the season from Jerry Oltion, and a fact article on climate changes by J R Dunn that's sure to stir up some controversy.

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BRASS TACKS

Dear Dr. Schmidt:

I'm afraid you've been hoisted by your own petard. Your comments in your May, 2000 editorial regarding the battle between passengers and airlines over carry-on luggage completely ignore the real source of the problem. Fussing about carry-on restrictions, allowances, size regulations, number of bags, total weight, etc. falls into the "Do something! Even if it's wrong, do SOMETHING!" school. It's a classic case of treating the symptoms rather than the cause.

Why do most airline passengers struggle to bring multiple pieces of often unwieldy luggage onboard the aircraft? Are we all really such gluttons for punishment? Answer: we don't like airports and we don't want to stay in them a minute longer than necessary. Not one airline in a single major city seems to be able to get checked luggage from the plane to the baggage claim area is less than 15-20 minutes. The typical passenger feels that if I can walk from the plane, through the myriad corridors of the airport, sometimes, as in Atlanta, having to rely on additional transportation to get to the baggage area, then the least the airline can do is to have my luggage waiting for me when I get there. Is that really too much to ask?

Since it's obvious that the airlines either can't or won't address this issue, then we, the passengers, literally take matters into our own hands and "do something, ANYTHING!" by carrying our luggage onto the aircraft. Of course it's the wrong thing to do, but when we arrive at our destinations, we take our luggage, get off the plane, and go straight out of the airport. No fuss, no muss, no waiting, no problem. It doesn't solve the real problem, but much like the Boston manager in the '60s who could only play the players that management gave him, we can only play the hand that the airlines deal us and thus we perceive that carrying our own luggage is a good thing because it's our best alternative when we have schedules to meet.

What the airlines have done is recognize that more and more of us want to carry more and more onto the aircraft and they've set aside more and more room to satisfy this trend. It seems to me that they either never investigated the reasoning behind the increase in carry-on, or they simply don't care to, or don't know how to address the real problem of how can we improve baggage handling.

Smaller airlines deal with this issue a lot better, as was brought home to us during a recent vacation to Tortola in the British Virgin Islands. Knowing that we had too much luggage to carry on, and figuring that if we had to wait for one bag we might as well wait for them all, we checked all of our luggage except for small hand items. When we got there, lo and behold, everything was waiting for us, neatly stacked, as soon as we got off the plane!

Can somebody please tell me why larger airlines at larger airports can't be this efficient? Didn't they ever hear of the concept of palletizing?

Instead of hand loading and unloading every bag into and out of the aircraft's

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baggage compartment, why can't they load everything onto a pallet or container which could be moved en masse to and from the aircraft? If they had to handle each individual piece of luggage only when the entire pallet got to the claims area, maybe our luggage COULD be waiting for us when we got there. Folks, this is not rocket science. It's borrowing the same labor-saving methods that have been used successfully by the trucking and railroad industries for years.

If one single airline could make it so that you could get off the plane, proceed to the claims area, pick up your luggage, and leave the airport without stopping, believe me, everyone would beat a path to their door, other airlines would be forced to follow suit, and the problem of too much carry-on luggage would all but disappear.

Ira Stoller
Butler, New Jersey
irastoller@juno.com

Sorry, I can't agree with your opening statement, even though I do agree that there's another problem that contributes to this one. But that's not the same thing as saying that the handling of carry-on luggage is just a symptom of something else. No matter how efficient *the handling of checked luggage might become, there will remain other legitimate reasons for wanting to carry some things on board. I, for instance, often carry manuscripts-in-process or exposed film, which are replaceable with difficulty or not at all and whose loss could not be adequately compensated by money; or photographic equipment which is easily damaged and whose use is an important part of what I plan to do at my destination, so I need it* when *I arrive. If it goes astray, I will not be satisfied to get it back* eventually; *I'm carrying it because I need it* now. *And things* will *go astray, at least occasionally, under even the most efficient real-world system. Therefore, no matter how good your checking system, some passengers will always have legitimate reasons not to want to let certain things out of their sight. So the carry-on system, too, needs to be efficiently, reasonably, and consistently run.*

For an intriguingly different perspective on this (and some potentially useful information!), read on . . .

Dear Dr. Schmidt,

I am a pilot for United Airlines and I sympathize with your carry-on baggage frustrations. I am responding to your editorial because I think you may find it amusing to hear the flip side of this issue from an employee's perspective. The employees also have to deal with management's "Do Something" directives. As a pilot, I see the boarding process but am not actively involved—I have cockpit duties to perform during this time, but time permitting, I have intervened to prevent leaving passengers at the gate who should be boarded.

From United's employee newsletter, "News Real," here are just a few of our "core objectives for 2000":

1. Move up to **6th** place for on time zero (push back from gate at scheduled dept. time).

Believe it or not, our management has created an "on time 5, on time 15, and an on time 30 statistic which is the root of your complaint. (excuse me, but if you're 30 minutes late how can you be "on time?") **Our station managers are awarded bonuses based on these statistics.** Apparently the original goal of just ON TIME was too hard so they lowered the bar. The 30-minute on time has been modified even more to include flights that are late arriving, but are "Turned" to leave in 30 minutes. The clock starts over in those cases and management gets an "On Time Zero" bonus for getting a late flight out in less than 30 minutes. To make the situation even more bizarre, I had a customer service rep try to close the aircraft door "5 min-

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utes early" to get an **on time** departure (we were 45 minutes late in, actually, but they wanted to turn us around in 25 minutes). This CSR was going to leave 5 full-revenue passengers and 10 company employees behind in order to be "ON TIME"? So I took the delay—meaning they listed "Flight Crew" as the reason we were not "On Time" and that way they didn't get a call from their supervisor (who is looking for his/her bonus). The CSRs (at the gate) do not share in these bonuses—they are being prodded into getting the results for their supervisors. So to get back to the boarding issue, when boarding early, the CSRs have time to police bags, but as boarding gets closer to the cutoff time for "ON TIME" the frenzy to get everyone physically on the aircraft begins. Their responsibility ends with getting the people on the plane—they want to close the aircraft door so they can note that the door was closed "ON TIME" This "ON TIME" issue also works against employees that show they can still get the aircraft turned around for departure while understaffed. If the aircraft is turned too quickly with full staffing, apparently that means it's over-staffed, so therefore staffing is cut back by one person. Quite often CSRs work 2 or 3 gates at one time—this works until we have more than one flight arriving or departing at the same time. Then there's no bag policing, no one to collect tickets, no one to drive the jetway to the plane, and they run from one gate to the next trying to cover for a lack of manpower. The baggage handlers on the ramp in Salt Lake are currently half staffed—I asked why and was told that management gets a bonus for coming in under budget—it must be a bigger bonus than the one they get for on time. Customers who are interviewed have supposedly indicated that they have a higher interest in departing from the gate on time vs. arriving at the destination on time! I have the feeling that "arriving at destination on time" was not given as a selection on the questionnaire. I can't believe that given the choice, a person would rather be denied boarding so that the flight could leave on time and arrive 15 minutes early at the destination because the pilots were able to take advantage of favorable winds and shortcuts in the route, vs. getting everyone on a few minutes "late," and arriving on time. We have the highest Denied Boarding stat of all the major airlines. Denied Boarding means that you were not allowed to board even though you had a ticket and were there at the check-in time! (Gee, things would run so much smoother if we didn't have all those customers.)

2. Improve customer satisfaction and loyalty. (repurchase intent goal increase to 39% domestic)

This statistic is taken from interviews done that ask about legroom, meals, and special seat designs. Boarding process concerns are not included in ANY of our surveys. (No complaints—everything's just fine, isn't it?) I could be wrong, but 39% seems a bit low if you really care about getting people to come back. It would seem that this also indicates that there must be plenty of passengers to go around if our concern is that low!

3. Improve "employee engagement."

That cute term means "attitudes about work that motivate performance" the goal for this year is to increase it 2% to bring it up to 48%. They rationalize this by saying that the 2% RATE of increase is commensurate to other companies with a high level of employee satisfaction. SO, am I missing something here? Doesn't 46% mean that more than half of our 100,000 employees are not happy and motivated?

Unfortunately, what I see from all this is that our boarding procedure is geared only to getting that door closed so that the stats will earn our management a bonus. I also notice that our managers don't want to change anything that might adversely affect their bonuses. Policing bags makes the flight more pleasant but does delay boarding and we

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wouldn't want that, would we?

My husband (who is also a UAL Captain) made the observation that "Corporate America" loves statistics, and links bonuses to them because they have a perception that people don't question bonuses linked to stats. **The "ON TIME" Departure** stat at United is the only number they have an effect on—once we are off the gate the arrival time depends on the pilots, the air traffic controllers, and weather. That's another reason, by the way, that you see planes pushed off the gate "on time" and sitting on the ramp even though they are not going to take off any time soon due to weather, or ATC delays. They are interested in customer satisfaction as long as it doesn't interfere with their own goals. (They are rewarding actions that are producing negative results.) And they don't ask questions that will have an unpleasant answer if the answer might interfere with their bonus.

After much searching, I have located a customer service address for you to respond to the next time you have a bad experience on United (if you fly United, that is.) Please give it to anyone you think might use it.

For Customer Service Representative Complaints or Compliments (at the ticket counter or at the gate).

WHQPO
P.O. Box 66100
Chicago, Ill 60666
(Mention the flight number, date and city in your complaint and enclose ticket stub if available.)

(This address was on a complaint form that was stashed under the ticket counter in Chicago, where no passengers would ever see it!)

Captain, 737
United Airlines

Dear Dr. Schmidt:

Thanks for the "Alternate View" in the April 2000 issue of *Analog*. I think, however, that it should be emphasized that the Einstein Gravitational Equation, involving the curvature and energy momentum tensors, does not predict the "Black Hole." The prediction of the possible existence of the "Black Hole" arises from Schwarzschild's solution to this equation for the spherically symmetrical case. The Schwarzschild solution is very popular mainly because of its mathematical simplicity. It is believed to be the first solution to predict the correct orbit of Mercury. However, there are several solutions, with or without "Black Holes" depending on assumption of several arbitrary constants of integration arising from the solution to the various differential equations involved. This was pointed out in the introduction to a doctoral thesis at the Technische Universität in Karlsruhe in 1976. Furthermore, in the Schwarzschild solution, the speed of light in the tangential direction differs from its value in the radial direction. This suggests a method for testing some of the solutions. It can be shown that at least one of the solutions with no "Black Hole" also predicts the correct orbit of Mercury. The solution I chose would exhibit a singularity only if the central object were compressed to zero radius.

Don Bradley
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Dear Dr. Schmidt,

In the Feb. issue in Brass Tacks an editorial comment was made that you believe that *Analog* is available in Braille. To my knowledge it is not. I have been receiving *Analog* on Talking Book flexidisks (recorded at 16 & 2/3 rpm) for years, and enjoying it very much. This is a service of the National Library Service for the Blind and Physically Handicapped (NLS). Within a year or two the format will be updated to half-speed (15/16 ips) four-track cassettes (playable on the NLS Talking Book machines—special sturdy tape players made available on loan), at which point I will no longer need the old Talking Book turntable I've had on indefinite loan from NLS.

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Thanks for years of wonder-filled material.

Gail Elaine Irons
Phoenix AZ

Dear Editors:

I just finished the May 2000 issue of *Analog* and was quite surprised to find an astounding number of typographical errors. Many of the errors were grammatical rather than misspellings. Perhaps your editorial staff is busy checking on scientific facts as opposed to basic sentence structure. However, careful editing of the features should be a priority. These mistakes not only detract from your many fine stories, they are a distraction to the reader. I hope you will take more care with the next issues. Other than this problem, I enjoy your magazine and look forward to receiving it each month.

Patricia Farren

No, we do not check "scientific facts as opposed to basic sentence structure"; we try hard to check everything. *However, our staff is quite small, and none of us are infallible, so some mistakes do slip through. We regret that, but I see no reasonable hope of getting errors down to zero, much as we would like to.*

However, I'm a little taken aback by your claim of having found an "astounding" number (a claim I haven't heard from anyone else). You don't say what kind of number you consider "astounding", or give examples of what you consider such errors, but I can't help wondering whether you might be overlooking some of the subtle differences between editing fiction and nonfiction. Many things are acceptable and even obligatory in realistic dialog or first-person narration, for example, that would be considered grammatical errors in a scholarly article. And please bear in mind that languages, including English, evolve. Split infinitives, for example, used to be considered an absolute no-no by English teachers (even though they were a standard part of the language as actually spoken), but it's been a long time since even most English teachers considered them mortal sin. There are times, in fact, when they're clearly preferable for clarity.

Dear Dr. Schmidt,

I have a reason for your editorial in the May issue: No acceptance of responsibility. The north Phoenix AZ area has a main East-West multilane street, Bell Road, which runs from the McDowell Mountains on the east to the Whitetank Mountains on the west, a distance of about 40 miles. It reasonably well defines the width of the Valley Of The Sun. Bell runs through a number of jurisdictions starting with Scottsdale on the east and ending in the county on the west. Nowhere on Bell is the speed limit over 45 miles per hour. You put your life in other's hands if you drive at the speed limit. There are roll-over accidents on Bell in 40 mile per hour zones. So, the drivers are scofflaws who take no responsibility for their actions. The various governments are scofflaws because they take no responsibility for enforcing the law. And they are not trying to increase seat-mileage sales. In toto: no one takes any responsibility for their actions.

David C. Martin
Sun City West, AZ

Dear Stan,

This may be a bit tardy, but I was prompted to write on the subject of "The Greenhouse Chill" when a letter about the story came up in Brass Tacks.

I am dismayed that this and other stories that have appeared in Analog take the official government line of Global Warming without question.

The Global Warming theory is distinguished from the Greenhouse Effect theory in that the latter explains the general atmospheric temperatures that we enjoy, while Global Warming is the theory that a small increase of a minor

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greenhouse-gas, Carbon Dioxide, will cause a strongly amplified additional warming component, via a positive feedback mechanism, that will result in disaster.

I would like to make more public the data and arguments that invite skepticsm about Global Warming, some of which were presented by Dr. Arthur Robinson of the Oregon Institute of Science and Medicine (*www. oism.org*).

In the past twenty years, contrary to what the NASA GISS graphs show, global temperatures have decreased slightly. Early in the 1900s, global temperatures did increase, but this was before the times of the greatest Carbon Dioxide production. During these past twenty years when human Carbon Dioxide output and concentrations in the atmosphere have been at their greatest, global temperatures have decreased slightly.

Since the increase in atmospheric concentration of Carbon Dioxide followed the increase in temperature (even in the GISS graph), the former could not have caused the latter. We might speculate that the global system could have swallowed all of mankind's Carbon Dioxide production, except that increased temperatures have caused higher atmospheric Carbon Dioxide concentrations due to lower solubility of the gas in the world's oceans.

In addition, global temperatures are now recovering from "The Little Ice Age" of the 1500s, and are still below their average for the past three thousand years. Global temperatures have been cycling up and down on an approximately 1000-year cycle. It is simply luck that they have held relatively steady for the past twenty years. In short, global temperatures have displayed no correlation with Carbon Dioxide increases, display remarkable correlation with the strength of the Sun's output, and are following a historical trend.

Doctor Robinson presents a review paper on this subject (all assertions are backed up with graphs and references), available at *www.oism.org/pproject/s33p36.htm*. There is also an enormously helpful recorded lecture by him available at *www.oism.org/oism/s32p686.htm*. This is a 7.5 MB download. To view it, extract the zip file to a temporary folder on your PC, using the stored directory structure. Drag and drop "index.htm" from the temp direct-ory into your browser (I used Netscape) and the lecture should start. It runs for most of an hour.

Doctor Robinson has organized a petition to oppose the Kyoto treaty, and 17,000 scientists and engineers have signed it. See *www.oism.org/oism/s32p31.htm* and *www.oism.org/pproject/*.

In looking up Professor Easton's websites in order to reply to his "Legacy of Prometheus" review, I uncovered a very interesting book of debates on modern political-scientific issues edited by him: *TAKING SIDES : Clashing Views on Controversial Issues in Science, Technology, and Society, Fourth Edition*. (*www.dushkin.com/catalog/0072359404.mhtml*). I would have liked to have seen the strong counterpoint put forth by Dr. Robinson included in Part 2 issue 5; "Should Society Act Now to Halt Global Warming?"

In the 1970's we had the "energy crisis", and we were told that we must ration hydrocarbons. Later in the seventies, the belief was in global cooling, due to a local minimum of global temperatures being reached at about those times, and we were told that burning hydrocarbons was the cause of this and that we would have to ration hydrocarbons. For ten years after that, global temperatures increased, and we were then told that (repetition left as an exercise for the reader).

So what should we "Act Now" to do? Prevent Global Warming or prevent Global Cooling?

James Wiebe ■

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UPCOMING EVENTS Anthony Lewis

26–29 October 2000
WORLD FANTASY CONVENTION 26 at Omni Bayfront, Corpus Christi, Tex. Guests of Honor—K.W. Jeter, John Crowley; TM—Joe Lansdale. Registration—$105 until 15 October 2000, then more. Info: WFC 2000, Box 27277, Austin, TX 78755. +1.512.835.9304 (voice), +1.512.835.7637 (fax), e-mail: fduartejr@aol.com; URL: http://2000.worldfantasy.org

10–12 November 2000
NOVACON 30 (British SF conference) at The Britannia Hotel, Birmingham, England, UK. Guest of Honour—Christopher Priest, Special Guest—Rog Peyton, Artist Guest of Honour—David A Hardy. Registration: £35. Info: Steve Lawson, 379 Myrtle Rd, Sheffield S2 3HQ, UK; e-mail: pat@cooky.demon.co.uk; URL: www.cooky.demon.co.uk/n30/n30.html

10–12 November 2000
TROPICON (South Florida SF conference) at Clarion Hotel, Hollywood Beach FL. Guest of Honor—Vernor Vinge, Artist Guest of Honor—David Cherry, FanHistoricon Speaker—David Langford. Registration: $25 until 30 June 2000. Info: Tropicon XIX, c/o SFSFS, Box 70143, Fort Lauderdale FL 33307-0143; e-mail: tropicon@sfsfs.org; URL: http://sfsfs.org/Tropicon/index.html

10–12 November 2000
TUS-CON 27 (Tucson area SF conference) at Best Western Executive Inn, Tucson AZ. Guest of Honor—Catherine Wells, Artist Guest of Honor—Liz Danforth, TM—Edward Bryant. Registration: $30 to 1 October 2000, $35 at the door. Info: TusCon, Box 26822, Tucson AZ 85726; +1.520.881.3709 or +1.520.293.1455. e-mail: basfa@azstarnet. com; URL:www.azstarnet.com/~basfa

17–19 November 2000
EXOTICON (New Orleans SF/media conference) at Radisson Hotel, New Orleans LA. Guests of Honor—James P. Hogan and Paul T. Riddell, Media Guest of Honor—Claudia Christian, Artist—Larry Elmore, Gaming Guest of Honor—Dave Arneson. Registration: $30 to 7/31/00, $40 at door. Info: e-mail: bigrobis@bellsouth.net; URL: www.exoticon.net

17–19 November 2000
ORYCON 22 (Oregon SF conference) at Doubletree Hotel Portland Columbia River, Portland OR. Guests of Honor—Kara Dalkey and John Barnes, Editor GoH—Gordon Van Gelder, Science Guest of Honor—Robert Forward, Guest of Honor—Gail Butler. Registration: $40 until 31 October 2000, $50 at door. Info: OryCon 22, Box 5703, Portland OR 97228; +1.503.774.1043; e-mail: kristyb@eloft.net; URL: www.orycon.org/orycon22

24–26 November
CONCAT 12 (Knoxville area SF conference) at Hyatt Regency, Knoxville TN. Guest of Honor—Charles de Lint, Artist Guest of Honor—Charles Vess. Registration: $25 until 1 November 2000, $35 at door. Info: ConCat 12, 316 E. Scott Ave., Knoxville TN 37917; +1.423.523.6986; e-mail: chloiea@mailexcite.com; URL: www.vic.com/~chloiea/ConCat.html. ■

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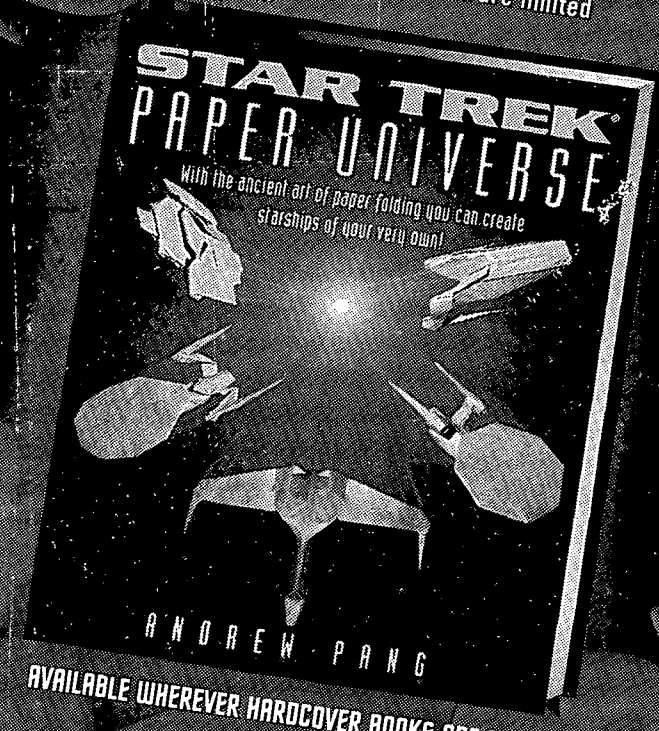

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